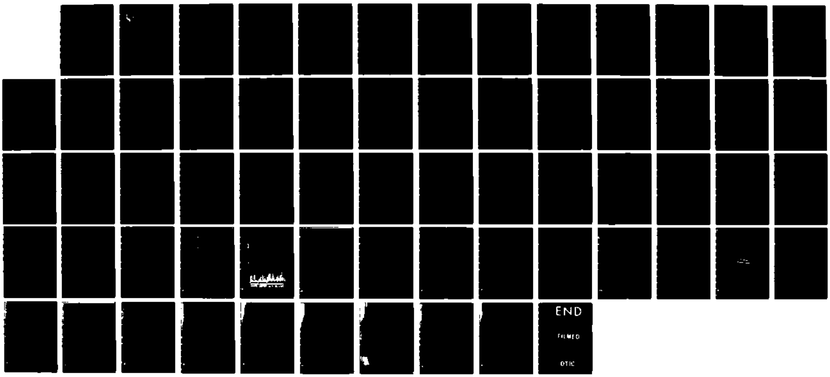
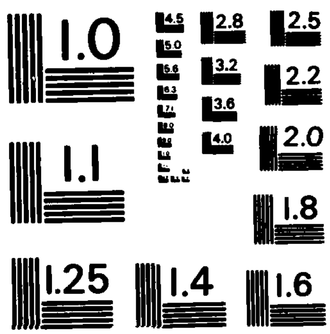
AD-A159 973 ARMY MAINTENANCE TRAINING AND EVALUATION SIMULATION SYSTEM (AMTESS) ENGINEERING DESIGN REPORT(U) GRUMMAN CORP BETHPAGE N Y* J H BEAKER 31 OCT 83 R85-1146 1/1

UNCLASSIFIED N61339-80-C-0151 F/G 5/9 NL

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SPECIFICATION NO.: 100-1

N61339-80-C-0151
R85-1146

US ARMY
MATERIEL COMMAND
PM TRAINING DEVICES

31 OCTOBER 1983

ARMY MAINTENANCE TRAINING AND EVALUATION SIMULATION SYSTEM (AMTESS) ENGINEERING DESIGN REPORT

PREPARED FOR:

U.S. ARMY PROJECT MANAGER FOR TRAINING DEVICES

NAVAL TRAINING CENTER
ORLANDO, FLORIDA 32813-7100

DISTRIBUTION UNLIMITED

Specification # 100 - 1

31 October 1983

ARMY MAINTENANCE TRAINING

AND

EVALUATION SIMULATION SYSTEM

(AMTESS)

ENGINEERING DESIGN REPORT

(SPECIFICATION)

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SYSTEM DESIGN SPECIFICATION

1.0 SCOPE

This design specification is intended to serve as a guide for defining a training system that satisfies the unique needs of different training situations while maintaining common elements in definition, authoring, courseware, firmware, software and hardware. This approach will result in a reduction of life cycle costs for the total training requirement. The objective is to give an overall controlled frame of reference for developing the various subsystems required to satisfy the training requirements.

2.0 APPLICABLE DOCUMENTS (to the extent specified herein)

MIL-T-23991	Training Devices, Military, General Specification for
MIL-STD-965	Parts Control Program
MIL-STD-143	Specifications and Standards; Order of Precedence for the Selection of
MIL-STD-470	Maintainability Program Requirements
MIL-M-82376A	Operation and Maintenance Manuals

3.0 REQUIREMENTS

3.1 Government furnished information. The contracting officer shall ensure that the contractor is provided with all information required for the design, development, and production of the trainer hardware, software, firmware, and instructional materials. This information shall be provided in a timely manner so that delays in its delivery will not impact work or delivery schedules.

3.1.1 Initial guidance. The contracting officer shall provide the contractor with written information identifying all authorized data collection sources and points of contact. This information shall include, at a minimum, the names of responsible individuals, their organizations, addresses, telephone numbers, and the nature of data collection or contact authorized.

Responsible individuals designated in this communication shall be knowledgeable about the training program to be supported by the trainer.

3.1.2 Documentation and materials. The contracting officer shall provide the contractor with all written documents and other materials which are required for development of the device(s) specified in the contract. Such documents and materials may include, but shall not be limited to, the following:

- Course syllabi
- Lesson plans
- Course and lesson evaluation data
- Supporting documentation for lesson plans
- Skill qualification tests (SQTs)
- Training schedules
- Job performance aids (JPAs)
- Skill proficiency aids (SPAs)
- Texts
- Training films
- Tests
- Commanders'/soldiers' manuals
- Technical manuals; operator and maintenance
- Contractor technical data
- Studies addressing or referencing the career field or training program
- Site environmental data; i.e., vibration, temperature, shock, sand, salt humidity
- Site electromagnetic interference
- Other site peculiarities; ie, available voltage, current, frequency and expected variations
- Other working data

3.1.2.1 Delivery. Initial delivery of documents and materials shall be made coincident with program start or as soon thereafter as possible. Additional documents and materials, identified after program start, may be required by the contractor. Upon approval by the cognizant government agency,

such materials shall be acquired and delivered as expeditiously as possible. Delivery of classified materials shall be made in accordance with restrictions specified below.

3.1.2.2 Classified material. The contractor shall not request delivery of classified material for which he does not have an appropriate storage facility, nor shall such materials be sent to the contractor by the government. However, on request of the contractor, such materials shall be made available for review by appropriately cleared contractor personnel at a government facility.

3.1.3 Subject matter experts (SMEs). The government shall provide SMEs to the contractor for scheduled visits and, on an as-required basis, for telephonic consultation. Sufficient numbers of SMEs shall be made available to provide a diversity of knowledge, background, and experience. SMEs shall possess a high level of both technical and training program expertise. If possible, SMEs should be selected who will be available for the duration of the project. If this is not possible, overlap of assigned SMEs shall be made such that there will be no break in program continuity.

3.1.3.1 Equipment demonstrations. Equipment systems to be simulated using the device shall be made available for inspection and use during scheduled contractor visits. SMEs shall also be made available during these visits, as discussed above, to answer contractor questions about the equipment and to provide other support as required.

3.1.3.2 SME/Contractor interaction documentation. Any modifications mutually agreed upon between SMEs and contractor personnel shall be duly recorded (as meeting minutes, telecons etc.) and submitted to the contracting officer for approval prior to incorporation into the device.

3.2 Front end analysis (FEA). The contractor shall perform a Front End Analysis using accepted Instructional Systems Development (ISD) methodologies. This analysis shall identify two-dimensional (2D) and three-dimensional (3D) design requirements for the skill(s) to be taught using the device, and shall be conducted for skills associated with either existing or emerging systems.

The FEA shall consist of three sub-analyses: task analysis, training requirements analysis, and fidelity requirements analysis. Specific requirements for each of these sub-analyses are addressed in a seperate subparagraph below.

3.2.1 Task analysis (TA). The contractor shall perform a Task Analysis to determine what tasks the trainee will be required to perform upon completion of training.

3.2.1.1 Data sources. The contractor shall use all available and applicable data sources in conducting the TA. The sources to be used will vary somewhat, depending on whether the skills being reviewed are associated with an emerging or existing system. The following sources are suggested for use, although different sources may be available, depending on the program.

3.2.1.1.1 Existing systems. The following should be considered as potential data sources for TAs on existing systems:

- SMEs
- Course syllabi
- Lesson plans
- Supporting documentation for lesson plans
- Skill qualification tests (SQTs)
- Job performance aids
- Skill proficiency aids (SPA)
- Texts
- Training films
- Logistics Support Analysis (LSA) data (3M, Readiness Reports, etc)
- Direct liaison with field personnel
- Tests
- Commanders'/soldiers' manuals
- Technical manuals
- Contractor technical data
- Studies
- System FEA data.

3.2.1.1.2 Emerging systems. The following should be considered as potential data sources for TAs on emerging systems:

- SMEs
- Contractor technical data
- LSA data (3M, Readiness Reports, etc)
- System FEA data
- Other working data as available.

3.2.1.2 Methodology. The contractor shall conduct the TA using ISD methodologies appropriate for the training application. The analysis shall be conducted to such a level of detail that it will identify all cognitive knowledge the student is to acquire and each psychomotor action he is to perform. This information shall be organized to show subordinate, superordinate, sequential, and parallel relationships.

Where more than one MOS/career field is to be taught using the same device, the contractor shall conduct a task commonality analysis between MOSs or career fields as a part of the TA. This analysis shall identify all common cognitive knowledge and/or psychomotor skills between the MOSs or career fields.

Using the task data described above, the contractor shall perform a task criticality analysis as the last part of the TA. Using SME inputs, studies, and all other appropriate data, a criticality rating shall be assigned to the TA data described above.

3.2.1.3 Outputs. The output of the TA shall consist of a structured list of cognitive knowledges and psychomotor skills. If the analysis has been done for multiple MOSs or career fields, the listing shall contain only elements common to all. Each element in the listing shall have a criticality factor assigned.

3.2.2 Training requirements analysis (TRA). The contractor shall perform a Training Requirements Analysis to determine which of the items

identified in the task analysis should be taught using the device and which items should be taught using other media.

3.2.2.1 Data sources. The contractor shall use all available and applicable data sources in conducting the TRA. The sources to be used for both an existing and an emerging system are identical, although more sources are likely to be available for an existing than for an emerging system. For an emerging system, it is possible to gain some insight from existing sources for other systems of the same type. The following sources are suggested:

- SMEs
- Task analysis output
- Course syllabi
- Lesson plans
- Supporting documentation for lesson plans
- Skill qualification tests (SQTs)
- Course and lesson evaluation data
- Tests
- Training schedules
- Studies.

3.2.2.2 Methodology. The contractor shall analyze the outputs of the TA with respect to data obtained from the above sources. This analysis will determine which items should be taught using an integrated 2D/3D training device. Among the factors that will indicate the use of such a device are the following:

- High criticality rating
- Items not currently taught because of equipment or instructor performance limitations
- Items not performed well by graduating trainees
- Items currently tested using inappropriate methods e.g., hands-on tasks with paper/pencil instruments
- Items having both cognitive and psychomotor elements
- Items requiring an extremely low student/instructor ratio

3.2.2.3 Outputs. The output of the TRA shall consist of a list of recommended training requirements for the device under development. This list shall be submitted to cognizant personnel for review and statements of concurrence or nonconcurrence with the recommendations. A final decision on device training capabilities requirements shall be made by the contracting officer after a thorough review of all information associated with the TRA. These capabilities will form the basis for all further design steps, and any changes to them shall be made in the form of an engineering change proposal (ECP).

3.2.3 Fidelity requirements analysis (FRA). The contractor shall conduct a Fidelity Requirements Analysis to determine media assignments on the device.

3.2.3.1 Data sources - The contractor shall use all available and applicable data sources in conducting the FRA. As in the TRA, the sources for both an existing and an emerging system are identical, but more limited for an emerging system. The following sources are suggested for use for the FRA:

- SMEs
- Task analysis output
- Training requirements analysis output
- Job performance aids
- Supporting documentation for lesson plans
- Skill qualification tests (SQTs)
- Skill proficiency aids
- Texts
- Training films
- Technical manuals
- Contractor technical data
- Other working data

3.2.3.2 Methodology - The contractor shall analyze Task Analysis data indicated by the Training Requirements Analysis to assign TA items to either the 2D or the 3D modules of the device. Rationale for assignment is as follows:

- o Purely cognitive items should be taught on the 2D with possible support from the 3D to demonstrate some concepts or as a training aid
- o Purely psychomotor items should be taught on the 3D with possible support from the 2D for use in modeling, remediation, feedback, etc.
- o Items involving both cognitive and psychomotor should be taught using both 2D and 3D on an interactive basis.

Items to be taught on the 3D require further analysis to determine the simulation fidelity requirements they impose on the various 3D components.

3.2.3.3 Outputs - The outputs of the FRA shall consist of two lists. The first shall list the requirements on the 2D, and the second shall list the requirements for the 3D.

3.3 Common modules. The common module subsystem is a family of hardware and software modules that can be configured in a variety of ways. The exact configuration will be dependent on the training situation, e.g., institutional training, unit training, reserve force training, organizational level training, DS/GS level training, or refresher training.

3.3.1 Common hardware modules. The common hardware modules encompass the 2D student work station and instructor station hardware. This hardware may be configured in various ways to make up a trainer for use in a specific training situation.

3.3.1.1 2D student workstation. The 2D workstation shall consist of all, or some combination, of the following hardware:

3.3.1.1.1 Basic structure. A single pedestal table shall be provided to house other items of workstation equipment and to serve as a work surface for students during training. Standard sliding drawers shall be provided in the pedestal for ease of equipment operation and service.

3.3.1.1.2 Host processor. A host processor shall be provided. The central processing unit shall be eight bit expandable to 16 bit CPU as required, with minimum random access memory (RAM) of 64K. Input/output and

internal interfaces shall be provided. An industry standardized bus structure shall be used in order to provide ease of expansion, multiple source integrated circuit card capability, and logistic support. Fifty percent spare memory and twenty percent of each different I/O (discrete input, discrete output, analog input, etc) shall be provided.

3.3.1.1.3 Mass memory data storage. Mass memory media for storage of lessonware and support programs shall be provided. The media may be either soft disk or hard disk, so long as the interface with the processing system is compatible and the data transfer speed does not adversely affect the fidelity of the presented data during on - line data transfer.

3.3.1.1.4 Videodisc player. Lesson materials in the form of motion sequences, still frames, and audio shall be designed and developed. These materials shall be recorded on one or more videodiscs to be presented to the student using a videodisc player under host processor control.

3.3.1.1.5 Power panel. Power controls and indicators shall be provided. The minimum indicators shall include an ON/OFF key switch, AC and DC indicators as used in the system, and a reset switch.

3.3.1.1.6 Student trainer interactive hardware. Simple, quick, and easy-to-understand student/trainer interaction shall be provided. A color television monitor shall be provided to display lesson materials from the videodisc player and/or computer-generated displays. The system shall be capable of presenting both types of displays independently or simultaneously on the screen. Hardware shall be provided to alert the host processor of the location of a student touch on the screen surface to a minimum resolution of one-fourth (1/4) inch.

3.3.1.2 Instructor station. The instructor station shall provide the capability to initialize the system, generate lesson source code, establish and maintain student records, generate student performance reports, monitor student progress, and insert preprogrammed faults. The instructor station shall, at a minimum, consist of the following:

- A processor compatible with the student station host processor
- A CRT
- A keyboard
- A printer.

In addition, the instructor station shall be capable of integrating a videodisc player, color television monitor, and touch screen for lesson authoring.

3.3.2 Common software modules. The training software system hierarchy shall consist of common modules, maintenance area peculiar modules, and additional applications modules. For purposes of this specification, the operating system, peripheral drivers and course execution modules will be considered as common modules discussed within this paragraph. The remaining modules will be discussed in paragraph 3.4.

3.3.2.1 Operating system. The elements of the Operating System shall communicate to any peripheral equipment interfaced to the computer system. Communication shall be accomplished with minimal effect on normal operational overhead of the system. The Operating System shall also function as a task manager, running each application program in a prescribed time interval to achieve optimum system performance. The operating system shall be capable of a real-time, or near real-time function.

3.3.2.2 Peripheral device drivers. Peripheral device drivers shall provide interface to the following:

(a) Disc Drives
(b) Videodisc Player
(c) Interactive CRT
(d) Touch Panel
(e) Keyboard
(f) Printer
(g) Voice Audio Subsystem
(h) Voice Recognition Subsystem
(i) Data Base
(j) 3D Simulator

(k) Application Programs

(l) Audio player

3.3.2.3 <u>Curriculum execution</u>. The system shall provide the necessary software to allow each student to progress through the course curriculum without instructor intervention. The following capabilities are included:

(a) Student sign-on

(b) Individualized lesson selection

(c) Student sign-off.

3.3.2.3.1 <u>Sign-on</u>. The system shall be capable of differentiating between three types of user: student, special student, and instructor. A student is a person who is using the system for initial learning of the subject matter to be taught; this type of individual requires a carefully structured learning experience. A special student is a person who is using the system for review; this type of individual requires access to any of a wide range of specific lesson materials. An instructor is a person who administers the use of the system, and who may have need to exercise lessons in a student mode.

A uniform sign-on procedure shall be used for all three types of users. This procedure shall require only that the ID number of the individual desiring to use the system be entered. This number shall consist of the social security or service number of the individual. The system shall accept entry of the ID number from any student entry device available on the trainer configuration being used. The system shall be capable of differentiating between the different user types on the basis of the ID number entered.

A text page shall be presented to view whenever the system is in a ready state and is not executing a segment. As a minimum, the page shall consist of general instructions on how to sign on. If the touch panel is to be used for sign-on, it will be necessary to include additional information and/or graphics on this display.

When a service number has been entered, the system shall be capable of determining whether or not the entry is valid, and will display an entry message on the student CRT if it is not. If the entry is valid, the system shall be capable of determining the user type (i.e., student, special student, or instructor). The system shall then perform as specified in the next subsection.

3.3.2.3.2 Lesson selection. The system shall accomodate lesson selection differentially on the basis of the user type, as follows:

(a) For a student, the system shall provide two options. It shall allow the student to retake lesson segments already completed, or it shall automatically progress the student to the next required lesson segment in the established course curriculum. The instructor shall have the option of overriding the first of these options as a part of the student monitoring functions provided by the system.

If the student selects the retake option, the system shall provide a menu of all previously completed lesson segments for that student. The system shall allow the student to indicate his choice using the same means as for sign-on, and shall also allow him to abort this option and elect the automatic option. When the student has selected a lesson segment to retake, the system shall initialize (download lesson software and establish initial conditions) and execute it.

If the student selects the automatic option, the system shall determine the next required lesson segment for that student. In doing this, the system shall be capable of selecting the next segment on the basis of the following:

- An absolute requirement as specified in the course curriculum outline
- Previous student performance
- Random ordering of segments, as specified in the course outline.

When the segment has been selected, the system shall initialize and execute it as specified above.

(b) For a special student, the system shall provide a menu of all lesson segments in the course curriculum. The system shall allow the special student to select and execute any of the lesson segments, as in the retake option specified for the regular student, above.

(c) For an instructor, the system shall perform as specified for the special student, except that the instructor shall be allowed to override initial conditions when beginning the lesson. Once he has begun, the system shall provide the instructor the option of moving to any point desired in the lesson. He shall also be able to exit the lesson segment at any point to sign off, as specified below.

3.3.2.3.3 Sign-off. When a user has completed a lesson segment, the system shall provide him with the option of signing off from the system. When he does this, the system shall perform normal record-keeping operations and display the sign-on page on the student CRT.

3.3.2.4 Course execution. The system shall provide the necessary software to permit the developed courseware to function effectively on the trainer. Common modules in this software shall provide for the establishment of initial conditions on the trainer simulator prior to beginning a lesson and shall alert students of the nature of unanticipated errors they have committed.

3.3.2.4.1 Initial conditions. The system shall ensure that the simulator is properly configured before beginning execution of a lesson. This configuration shall be uniquely specifiable for each lesson. The system shall compare the state of each control, connector, etc., on the simulator with a table of required states and shall notify the student of any deviations using the student station CRT. When the student reconfigures a component to the proper position, the message for that component shall be removed from the CRT. When all components are properly configured, the lesson shall begin.

3.3.2.4.2 Error handling. When the student performs an action on the simulator that has not been anticipated in the lesson software, the system

shall immediately display an error message on the student station CRT. This message shall:

- o Inform the student that he has committed an error
- o Inform him of the component involved
- o Inform him of the component's present state
- o Inform him of what he needs to do to remove the error.

3.3.2.5 <u>Student record keeping</u>. The system shall maintain records for each student using the system. Two types of information shall be kept in these records: student personal information and curriculum-related information. Student personal information shall consist of the student's name, rank, service (ID) number, and the course in which he is enrolled.

Curriculum-related information shall consist of the following segment-specific data for each lesson segment the student has completed:

- o Date/time student began the segment
- o Date/time student finished the segment
- o Time required to complete the segment
- o Number of errors committed in the segment
- o A performance index for the segment.

The performance index shall be computed using the number of student errors and elapsed time for the segment relative to average numbers of errors and average elapsed time for the segment.

In addition to the lesson segment specific information required above, the system shall record the following curriculum-general information:

- o Date/time the student first used the system
- o Date/time of most recent system use
- o Cumulative curriculum performance index
- o Average number of errors per lesson segment
- o Average time required to complete a segment
- o Total time spent on the system

- o Total lesson segments completed
- o Number of segments unsatisfactorily completed.

3.3.2.6 <u>Report generation</u>. The system shall provide performance data reports to an instructor upon request via the instructor station keyboard and CRT. It shall be capable of displaying these reports on the student station CRT and of generating hard copy printouts on the instructor station printer. The mode of display shall be at the option of the instructor requesting the report.

3.3.2.6.1 <u>On-line reports</u>. When so required by the instructor, the system shall display student performance data on the instructor CRT. Report formats shall be provided for individual student inquiries and for class inquiries.

3.3.2.6.1.1 <u>Individual student inquiries</u>. Two report options shall be provided for individual students: a history inquiry and a performance profile.

(a) History inquiry. This report shall provide specific information concerning the entire performance history of the student. The student's entire personal information record shall be included at the top of the report. Following this information, an itemized listing of the following segment-specific data shall be presented for every lesson segment completed by the student:

- o Segment designator and name
- o Date of completion
- o Time required to finish the segment
- o Number of errors committed in the segment
- o Performance index for the segment.

When the student history is too long to be viewed in its entirety on the screen, the system shall paginate the report and provide a means for the instructor to page through the entire report in both the forward and reverse directions. Page numbers shall be incorporated into the page display.

(b) Student performance profile. This report shall provide summary information concerning the performance history of the student. All curriculum-general information, as specified above, shall be included.

3.3.2.6.1.2 Class inquiries. The system shall provide class reports for display on the instructor station CRT when requested by the instructor. These reports shall include the information specified above for the individual student performance profile report. The report shall be formatted so that all members of the class requested are displayed on the screen simultaneously. In cases where there is too much information to be displayed on the screen at one time, the system shall paginate the report as specified above for the student history report.

3.3.2.6.2 Off-line reports. The system shall provide the instructor with the option of requesting off-line reports using the instructor station hardware. These reports shall be printed using the instructor station printer. The report types include all of the on-line reports, and in addition shall provide an option to print history reports for all of the students in a class.

3.3.2.7 Record maintenance. The system shall provide instructors with the capability to maintain instructor, student, and class records using instructor station hardware. Four capabilities shall be provided:

- Adding instructor and student records
- Modifying student records
- Deleting instructor and student records
- Reactivating inactive records.

(a) Adding records. The system shall allow an instructor to register individuals as an instructor, as a student, or as a special student. It shall require the instructor to enter all student personal data for each entry, and shall record the date and time of registration as a permanent part of the record.

(b) Modifying records. The system shall allow an instructor to modify the personal information in a student record. The instructor shall be prohibited from changing any other information in the record.

(c) Deleting records. The system shall allow an instructor to delete instructor and student records from active status. Two capabilities shall be included: deleting an individual record, and deleting all records for an entire class. When deleting records, the system shall require the instructor to confirm the record before executing the deletion. The deletion shall not eliminate the records from existence, but shall put them into an inactive status.

(d) Reactivating inactive records. The system shall allow instructors to reactivate records that have previously been deleted from active status.

3.3.2.8 Instructor intervention. The system shall allow an instructor to intervene in any student's progress through the curriculum. It shall allow him to do the following:

- o Require a student to retake a previously completed lesson segment
- o Require a student to start over at a previously completed point
- o Require a student to take an optional segment
- o Allow a student to skip required segments in the curriculum.

3.3.3 Common hardware/software configuration. The common hardware and software modules shall be configured as required by the intended trainer usage. The following represent the range of anticipated uses as presently envisioned:

- o Institutional Training
- o Unit Training
- o Reserve Force Training

3.3.3.1 Institutional training is performed at a service school for full-time students. This category of training requires the full capabilities of the system, with all hardware and software configured for the specific MOS

being taught. Full software capability shall exist to permit tutorial, guided practice, help-on-demand, and examination types of instructional approaches.

3.3.3.2 Unit training is performed in operational, active Army units for MOS qualified and OJT personnel. The system shall treat OJT personnel as regular students in an institutional setting. MOS qualified students will use the system in this setting to learn aspects of maintenance with which they are unfamiliar and to refresh their skills in areas where they have not worked for some time; consequently, they shall be regarded as special students. This category of training requires all of the hardware and software capabilities required for institutional training. In addition to these requirements, all hardware shall be ruggedized to withstand the particular environmental conditions of the type of unit with which the equipment will be deployed.

3.3.3.3 Reserve Force training involves unit training for reserve personnel who have limited contact with equipment on a day-to-day basis. The primary difference is that there is a proportionately higher number of regular students relative to special students. Common hardware and software requirements are approximately the same as for unit training.

3.4 Maintenance area peculiar module subsystem. The maintenance area peculiar module subsystem shall consist of all hardware, software, firmware, and lessonware designed and developed for instruction in a specific maintenance area.

3.4.1 Maintenance area peculiar hardware. This hardware consists of all the 3D simulator hardware. The following list is typical of the hardware used for this purpose:

- potentiometer (infinite variations)
- meters (infinite variations)
- rotary switches (many variations of number of positions, number of poles, degrees between positions, etc)
- toggle switches (many variations of number of poles, number of throws, momentary, locked in, locked out, etc)

- o pushbutton switches (momentary push-push, variations in number of poles, etc)
- o door interlock switches (numerous variations)
- o circuit breakers (single, dual, triple, variations in sizes, shapes, trippable, non-trippable, etc)
- o connectors (many variations as to size, shape, number and type of pins, etc)
- o CO-AX connectors
- o test jacks
- o indicators (unending variety of types, lamps, messages, etc)
- o structure
- o cables and cable interfaces

Maintenance area peculiar hardware shall be carefully selected on the basis of the fidelity requirements analysis, and shall also consider hardware used in other related trainers with the objective of attaining as much commonality as possible without compromising the quality of training that can be delivered.

3.4.2 Maintenance area peculiar software. This software is used to drive the simulator and replicates actual equipment function to the degree determined by the fidelity requirements analysis. This software shall be developed from math models specific to the piece of equipment simulated. It requires coding, debugging, and integration with the simulator hardware. This software shall not make any judgments relative to the correctness of student actions, as this function is performed by software common modules as specified in the previous section.

3.4.3 Maintenance area peculiar firmware. The object code for the maintenance area peculiar software specified in the previous subparagraph shall be permanently or semi-permanently stored on read-only-memory (ROM) chips. These chips shall be included as a part of the maintenance area peculiar hardware. The chips themselves may be considered common up to the "data-burning" process, at which point they take on a peculiar signature applicable only to the specific application for which they are to be used.

3.4.4 Maintenance area peculiar lessonware. Lessonware shall be prepared as actual lesson materials designed and developed to satisfy specific training objectives using a particular trainer configuration. These materials shall be stored as video and audio information on a videodisc and/or as computer generated images. Specific programs shall be prepared using the authoring language in the additional applications subsystem to sequence the presentation of these materials. The system shall be capable of intermixing the presentation of these materials with anticipated student actions on the simulator. At a minimum, the system shall be capable of providing the following instructional formats:

- o Tutorial, in which information is presented at a pace determined by student responses at the student station
- o Guided practice, in which instruction is intermixed with student practice of the skills taught
- o Semi-independent action, in which help specific to the next required student action is available on request
- o Independent action, in which the student must function without help from the system, other than being alerted of incorrect actions.

3.4.5 Maintenance area common subassemblies. The 3D Simulator microprocessor subsystem shall be common to all simulators. This subsystem shall consist of common hardware selected in specific quantities to make up the appropriate trainer configuration. The common parts used in the microprocessor design are as follows:

- o Multibus configured card cage
- o Central Processor Unit
- o Memory board
- o Discrete Input/Output board
- o Analog Input/Output board

3.4.6 Input/output capability. The input/output system of the computer equipment shall have sufficient speed and channel capacity to enable input/output operations to proceed without disrupting or degrading the simulation operation. To satisfy this requirement, each computer input/output system

shall include, but not be limited to, the following capabilities and provisions:

a. Capability to communicate directly with digital peripheral equipment specified.
b. Capability to control the input or output, to one or more units of peripheral equipment while the trainer is in operation.
c. An error checking feature to check input/output transfers.
d. Means by which the computer can be externally interrupted.
e. Capability to service interrupts in a priority structure, to properly process simultaneous interrupts, and to enter computer program service routines for interrupts processing.
f. Capability to communicate with those interfaces for which the computer processes and controls information.
g. Capability to communicate with all computers for which data transfer is necessary.

3.4.7 Interface. The Maintenance area peculiar modules shall interface with the common module subsystem by way of a simple RS232C serial communications channel. The serial channel communicates between the common CPU and the area peculiar CPU.

3.4.8 Tracking. By definition, the maintenance area peculiar subsystem will consist of a relatively large number of unrelated end items. These items shall be grouped as to functional capabilities and tracked accordingly.

3.5 Additional applications subsystem. The additional applications subsystem shall consist of elements required to generate lesson software for new applications. It is made up of the lesson authoring language and the authoring editor.

3.5.1 Language. The authoring language used for off-line development of lesson materials shall provide a command structure and syntax to author source lesson files that can be assembled to produce object lesson files. The object lesson files shall be used by the lesson processor to provide structured

learning experiences for trainees. Commands shall be provided for six functions:

- Lesson execution
- Lesson variables
- Instruction
- Student interaction
- Simulator communication
- Instructor communication.

3.5.1.1. <u>Lesson execution</u>. The lesson execution commands shall provide organization to the lesson source code files and determine, in part, the order in which instructional events take place in a lesson segment at run time.

3.5.1.1.1 <u>Lesson organization</u>. Source code files shall be divided into a series of EVENTs. These EVENTs shall consist of a block of commands that are to be treated as a single entity. The commands in an EVENT shall define the total range of correct and anticipated incorrect actions a student is allowed to take at a given point in a lesson segment. They shall also provide for any other instructional or programming requirements at that point. The authoring language shall include a means of providing all EVENTs with a unique identifyer.

3.5.1.1.2 <u>Branching</u>. The authoring language shall provide a means of branching to any EVENT in a given lesson segment. A minimum of three branching capabilities shall be provided:

- Absolute branch
- Branch on value of a lesson variable
- Branch on state of simulation models.

3.5.1.1.3 Calls to subroutine. The authoring language shall provide for the use of subroutines. A means shall be provided in the language structure for designating the beginning and end of each subroutine. The language shall allow a lesson author to specify the subroutine to be executed and the specific EVENT within the lesson segment to go to when execution of the subroutine is complete. A means shall also be provided to change the return EVENT specified. The language shall allow the author to use nested calls.

3.5.1.1.4 Restart. The language shall allow the author to specify restart points within a lesson segment. When the lesson returns to a restart point, the system shall require the student to configure simulator controls as they were at that point before continuing with the lesson.

3.5.1.1.5 Delays. The language shall provide a means for delaying transfer of lesson control to a specified EVENT. Time duration of delays shall be variable and specifiable to within one-tenth of a second.

3.5.1.2 Lesson variables. The authoring language shall provide the author with a minimum of 32 variables for the storage of numeric and alphabetic data. It shall allow the author to designate a descriptor for each variable by which it can be addressed. At a minimum, the language shall allow the author the following capabilities:

- o Assignment of an absolute value to the variable
- o Incrementing and decrementing a numeric variable
- o Assignment of random numbers to a numeric variable
  - With replacement
  - Without replacement in a specifiable range.

3.5.1.3 Instruction. The authoring language shall provide a means for presenting instructional materials on the student station CRT. These materials shall consist of video images from the student station videodisc player and/or computer generated generated images. Images shall be presentable as videodisc images only, computer images only, or mixed video and computer images. Videodisc images, whether presented alone or mixed with computer images, shall be presentable as follows:

- o Still (single frame) images
- o Motion
  - Forward, 30 fps, video without audio
  - Forward, 30 fps, video with audio track 1
  - Forward, 30 fps, video with audio track 2
  - Forward, 30 fps, video with audio tracks 1 and 2
  - Forward, 30 fps, no video with audio track 1
  - Forward, 30 fps, no video with audio track 2
  - Forward, 30 fps, no video with audio tracks 1 and 2
  - Forward, slow motion variable from 1 fps to 15 fps
  - Reverse, 30 fps
  - Reverse, slow motion variable from 1 fps to 15 fps
- o Animation (rocking between adjacent frames on the videodisc).

Computer generated images shall be presentable as text (including numbers), lines, rectangles, and circles. A minimum of sixteen colors shall be provided. When presented over videodisc images, geometric computer images shall be capable of totally occluding the videodisc image or of giving a translucent effect, where the videodisc image is partially occluded and both images can be seen simultaneously.

3.5.1.4 Student interaction. The authoring language shall provide for branching on student actions. At a minimum, the command structure shall provide for student inputs from all types of student station hardware provided on the trainer (touch panel, voice recognition, key pad, etc.) and from student manipulations on the simulator. In addition, provision shall be made for branching when the student makes no response in a specifiable time limit. The system shall allow mixing of all three types of interaction in a single EVENT.

The system shall allow the author to designate anticipated responses as either correct or incorrect. Up to 32 correct responses and 16 incorrect responses shall be specifiable in a single EVENT. When the student makes an incorrect response, the system shall automatically increment an error counter.

3.5.1.5 Simulator communication. The authoring language shall allow the author to manipulate variables in the simulator's modeling software.

3.5.1.6 Instructor communication: The authoring language shall provide the capability at any point in a lesson segment of specifying a message to be displayed on the instructor station CRT.

3.5.2 Editor. An editor shall be provided that will allow authors to generate source language files quickly and efficiently. It shall allow for extensive internal documentation of source code files.

3.6 General System Requirements.

3.6.1 Reliability, availability and maintainability (RAM) and RAM design analysis.

3.6.1.1 Reliability analysis. The reliability analysis of the system and equipment shall be an integral part of the overall trainer analyses to obtain a compatible and effective system tradeoff balance. Analysis coverage shall include, but is not necessarily limited to:

- Modeling
- Allocations
- Predictions.

3.6.1.2 Parts reliability. Parts and materials used shall be in compliance with the parts control program outlined in MIL-T-23991 and MIL-STD-965. Modified off-the-shelf equipments shall be included in the parts control program. Parts and modules listed in MIL-STD-143 Group I shall be considered standard. MIL-STD-143, parts Groups II, III, and IV, will be used only after obtaining customer approval per MIL-STD-965 Procedure I. Parts selection and application shall be evaluated during design reviews.

3.6.1.3 Reliability critical items. Reliability critical items, i.e., items that exhibit failure rates much greater than predicted, shall be tabulated. A copy of the tabulation, updated as required, shall be maintained,

and appropriate action for each item directed and monitored by program management. Items shall remain as open action items until resolved satisfactorily.

The tabulation shall identify the item by part number, nomenclature and manufacturer. In addition, the action required designee, action completion target date, actual complete date, and open-closed status shall be tracked.

3.6.1.4 Maintainability analysis (Paragraph 5.2 of MIL-STD-470). Maintainability analysis shall be performed as part of the overall system and equipment analysis. The maintainability analysis provides qualitative and quantitative definition of the maintainability design features to be included in the hardware. During the course of design, system and equipment features and characteristics shall be evaluated to determine the degree to which the maintenance concept and maintainability design requirements are being achieved. Software programs, developed to identify and isolate faults in the 2D and 3D stations, shall be evaluated in conjunction with hardware BIT design.

3.6.1.5 Maintenance concepts (Paragraph 5.3 of MIL-STD-470). The concept for the maintenance of the trainer is to provide proper maintenance services with a minimum of interruption to training missions. As a goal, preventive maintenance shall be performed during off hours when the trainer is not being used to perform its primary training function. Daily readiness testing shall be performed prior to the start of a training mission day. Diagnostic testing shall be used to locate and isolate failed trainer replaceable assemblies as a means of minimizing downtime. When the trainer is being used in a training exercise, corrective maintenance or maintenance actions for nonmission essential problems that will interfere with ongoing training will not be performed. Three basic levels of maintenance shall be considered: on-line and off-line organizational and depot/contractor maintenance.

3.6.1.5.1 On-line organizational maintenance. Maintenance at this level shall be performed on-line, and will consist of both preventive and operational type maintenance tasks. It will consist of:

- o Daily Readiness Test - to verify the integrity of the system
- o Diagnostic Tests - to isolate to a faulty module or subassembly
- o Remove and replace faulty modules or subassemblies
- o Verification that the trainer has been restored to an operational status.

3.6.1.5.2 Off-line organizational maintenance. Maintenance at this level shall be performed primarily on modules or subassemblies that have been removed from the trainer because of parts failure. The primary function will be to:

- o Isolate the actual failed part of any board, assembly, or minor subsystem
- o Repair or replace the failed part
- o Test and verify that the removed assembly is satisfactory for return to inventory or to the trainer.

3.6.1.5.3 Depot/contractor maintenance. Maintenance at this level shall be performed off-site by depot or contractor personnel. It will consist of the repair or replacement of complicated or specialized parts, assemblies or subsystems.

3.6.2 ILS provisions. The integrated logistic support concept is specified in ANNEX I.

3.6.3 Operating environment requirements. The operating environment shall be in accordance with MIL-T-23991 unless otherwised specified in the detail design specification for the specific trainer. Environmental consideration shall include the following:

- o Temperature
- o Humidity
- o Shock
- o Vibration
- o Salt air
- o Sand

o EMI

In addition power availability shall be considered, i.e., voltage, current frequency and variations of same.

3.7 Interface Control Specification. The interface control specification is presented in Annex II.

3.8 Summary of Cost Projection Assessment. A cost projection assessment is provided for the purpose of evaluating and optimizing Life Cycle Cost (LCC). The cost projection assessment is an extension of the Life Cycle Cost and Design to Unit Production Cost (DTUPC) assessments conducted under Phases I & II. Subsystem cost assessments have been developed in accordance with the Army LCC Matrix cost elements defined in DA Pamphlets 11-2, 11-3 and 11-4. Ranges of cost have been allocated for each subsystem and component assembly. Cost allocations highlight recurring and non-recurring costs, cost drivers for R&D, Investment and O&S phases and critical system requirements (e.g. Reliability, Maintainability, ILS, environment, etc.). These assessment activities are not intended to constitute an exhaustive survey of all possible specific elements of cost but to show the methodology and tradeoffs used in allocating LCC for each subsystem and components.

The procedure for providing the cost projection assessments is described in ANNEX III, Cost Projection Assessment. Examples are provided by two units: a highly complex missile radar and a lower complexity automotive system. These are used to illustrate the range of costs to be expected during full scale production. Typical equipment breakouts are shown together with assumptions and ground rules used in developing the cost projection assessments. Results are given showing the relative costs of each cost element in the Army LCC matrix. The relative unit LCC versus production quantity for both types are also given. Cost allocations and drivers are indicated in various pie charts showing relative costs by phase (R&D, Investment and O&S), costs within each phase, R&D Software/Courseware versus hardware, 2-D versus 3-D hardware cost and 2-D and 3-D hardware cost drivers. These will be used to evaluate costs and determine those areas where cost reduction efforts will be most effective.

ANNEX I

INTEGRATED LOGISTICS SUPPORT CONCEPT

1.0 The Integrated Logistics Support Concept (ILSC). The ILSC includes consideration of a general maintenance concept, levels of maintenance, support documentation, field support and spares.

1.1 Maintenance concept. The maintenance concept for the trainer device system will emphasize "remove-and-replace" rather than "repair-on-equipment" procedures at the system level. This concept shall provide maintenance services with a minimum of interruption to training missions and it is fully supported through the device hardware and software design. Although 100% application of remove-and-replace-only maintenance may be neither technically nor economically practical, a balanced application of this concept with some on-equipment restorative actions is an extremely powerful factor in increasing operational readiness. When this concept is integrated with optimum base/self-sufficiency for bench check and limited repair of removed parts, this concept is cost effective. The key aspect emphasized here, however, is the replacement of defective assemblies to maximize training device availability rather than to attempt repairs while installed.

Preventive maintenance is performed during nontraining periods at prescribed intervals. Prior to daily usage, the operational integrity of the trainer is verified by the daily readiness test (DRED). BIT will provide the vital online fault detection and isolation capabilities for the rapid repair turnaround time considered essential to achieve high overall trainer utilization and mission availability performance. BIT will combine hardware and software to provide the stimuli, logic, and measurement functions needed to assess trainer operational performance and isolate faults to trainer replaceable units (TRUs). The replaced TRUs will be repaired on-site or by a designated vendor.

1.2 Levels of maintenance.

1.2.1 Basic support tasks. The basic hardware and software support tasks to be performed are:

- Visually inspect the trainer for damage, and clean and maintain exterior surfaces
- Perform Daily Readiness Tests (DRED)
- Perform verification of all technical data, drawings, software, support documentation and lists provided with the trainer
- Perform preventive maintenance including:
  - Cleaning (as required)
  - Inspecting (as required)
  - Replacing/cleaning filters periodically
  - Adjusting/checking components
- Perform on-line repair actions (i.e., removal and replacement of TRUs)
- Repair TRUs
- Maintain associated support equipment
- Exercise configuration controls for the trainer hardware, software, associated support hardware, and documentation
- Provide inventory controls which include issuing stock, compiling usage data and maintaining inventory and property records.

1.2.2 Organizational level maintenance. During the interim support period, the maintenance concept proposed for organizational (on line) maintenance separates the work effort into two groups which take advantage of the basic system architecture:

Group 1 is the effort to be performed by the Instructor/Operator
Group 2 is the effort to be performed by the Army's maintenance personnel.

Since the instructor is closely involved in a monitoring role during the conduct of training and is therefore in a position, at the Instructor Station, to observe the general equipment operational status, Group 1 includes monitoring and reporting degrading equipment performance to the trainer maintenance

technician. Group 2 includes the start of day daily readiness test (DRED) and equipment status and set up requirements. DRED will provide a complete operational status check for the entire device. A GO condition on this test indicates that the device is operationally ready for training. A NO-GO would result in a display indicating a system malfunction. Further fault isolation would then be undertaken through the application of the system diagnostic tests to identify the faulty assembly. Once this has been completed, the required replacements can be made and normal operation restored. Except for minor adjustments, there will be no TRU repairs effected at the on-line organizational level of maintenance. Additionally, any corrective maintenance actions required, due to malfunctions, during the normal training day would fall into Group 2.

1.2.3 Intermediate level maintenance. The intermediate level maintenance (off-line organizational maintenance) concept is to repair the repairable TRUs and return them to the spares inventory at the respective site. Determination of which TRUs should be repaired on-site will be based primarily on the results of a trainer level of repair analysis (LORA). Other considerations would include status of the required on-site support equipment; current on-site maintenance back-log; availability, on-site, of the necessary spare parts, etc. Initial contracts with the contractor's subcontractors/vendors shall include provisions for providing back-up intermediate level support on an as required basis.

At the start of the interim support period, all on-site repairs will be performed by contractor personnel. This effort will be transitioned to the Army as the interim support period progresses. This will ensure that, as the conclusion of interim support, Army technicians will be adequately trained to maintain the trainer.

1.2.4 Depot maintenance. Depot level maintenance (depot/contractor maintenance) consist of the off-site repair or replacement of failed assemblies which are beyond the repair capabilities of on-site maintenance. Contractor off-site maintenance requirements will be primarily determined from the LORA results. The LORA will identify those assemblies which are considered to be economically and/or technically impractical to repair

on-site. These assemblies will be shipped back to either the Contractor or the respective vendor for repair, exchange and/or replacement. A critical spare will be replaced, while non-critical spares will be repaired and then returned to the site as ready-for-issue stock.

1.3 Support documentation.

1.3.1 Theory of operation. The theory of operation section shall describe the entire system and present information describing how the purchased, off-the-shelf, equipment is interfaced/integrated into the total trainer design.

1.3.2 Troubleshooting approach. The prime purpose of the troubleshooting will be to provide rapid on-line organizational location of a defective assembly that can be changed quickly with a spare provided with the trainer. To accomplish this, this section will make maximum use of delivered computer diagnostic programs for self check of the computer and its associated computer peripherals and also will make maximum use of the daily readiness tests (DRED), which will be prime contractor developed to check the remainder of the system.

1.3.2.1 On-line troubleshooting. Because the computer is the heart of any trainer, troubleshooting will first look to the computer system for a hardware malfunction, whether it be a temporary glitch such as caused by a power drop, some other malfunction that can be readily corrected by a reset, or something of a more serious nature. If a more extensive problem exists, the diagnostics will be sequenced so the maintenance technician can begin with the most logical test and proceed through in sequence. In addition, the user will be referenced to the detailed commercial diagnostic manual that will be provided as a supplement; however, within the basic manual a printout of what correct diagnostic should be will be provided. Manual troubleshooting procedures will be provided to permit the technician or the user to isolate a malfunction in areas where, after running diagnostics, no failure is detected or where it is impossible to utilize the machine capability due to a tape or disc malfunction.

After the computer and its peripheral troubleshooting, the next step will be to utilize the DRED system to provide a quick check of other system components. The DRED procedure will be structured to include an additional column that will have adjustments, remarks, or references to particular test points and diagrams that permit more rapid troubleshooting and isolation. A form of matrix chart keyed to the DRED will be generated, to define the most likely malfunction caused by a failure of a particular circuit card and cross-referencing from symptom to circuit card. The trainer will be provided with an interim support items kit which will contain one of each type of circuit card as a spare; thus, the user may remove the suspected defective card and insert a known good as part of his troubleshooting procedure.

Complete procedures shall be provided that permit reading or writing into memory, permitting troubleshooting of non-circuit card type system parts such as switches, lamps, etc.

As a final on-line troubleshooting tool wiring diagrams, wire lists, schematics, logics, and functional diagrams shall be available to do detailed troubleshooting procedures utilizing oscilloscope and meters.

1.3.2.2 Off-line troubleshooting. Off-line troubleshooting (intermediate level) will be done on the test equipment specified for contractor designed cards and will make use of the vendor manuals/procedures for troubleshooting of vendor components to the lowest level assembly the vendor will accept for repair (generally a circuit card assembly). The LORA will determine the lowest level piece to be repaired. Each unique circuit card or assembly on the trainer will have troubleshooting and test procedures.

1.4 Field support.

1.4.1 Field operations. The Field Operations representative reporting directly to the ILS Manager, will be responsible for managing and coordinating the proper selection and quantities of logistics resources (e.g., personnel, publications, support equipment, etc) necessary to effectively support the devices during the interim support period. He will assist as necessary in such efforts as:

- o Trainer installation and checkout
- o Validation of publications
- o Customer liaison during the interim support period (ISP)
- o Maintenance and update of documentation on-site during the ISP.

1.4.2 Supply operations. Supply Operations will be responsible for the identification, acquisition, management, delivery, and control of support material, including:

- o Spares/Repair Part
- o Provisioning Documentation
- o Inventory Control Functions
- o Spares Deliveries and Status Reporting
- o Customer Repairs.

The Supply Operations organization will be also responsible for all provisioning documentation and other supply related data specified in the contract, including vendor procured data. Additionally, it will generate and implement a plan for repair parts support during the interim support period. This plan will include repair-of-repairables procedures, inventory control, and pipeline requirements to ensure a timely and orderly flow of repair parts to the trainer site. Also, it will recommend the designated repair facility (i.e., on-site, at Grumman, or at the vendor's facility).

1.4.3 Level of repair analysis (LORA). The LORA Group will be responsible for generating and implementing the LORA in accordance with the contractual requirements. Its primary in-house interfaces, external to the ILS organization, will be reliability, maintainability, human factors, safety and trainer system design engineering personnel.

1.4.4 Site requirements. The Site Requirements Group will be responsible for determining all facility and installation requirements of the trainer. It will prepare the Trainer Facilities Report. It will participate in the installation and checkout of the trainer in order to identify and assist in resolving any facility or installation problems that may arise. It will plan and coordinate the on-site installation and testing of the trainer system.

1.4.5 Support equipment. The Support Equipment Group will be responsible for the identification, selection, and timely delivery of any support equipment or special tools and test equipment that may be required for on-site support of the trainer during both scheduled and unscheduled maintenance. It also will be responsible for the proper generation and delivery of all contractual data and material items (including the test program sets) associated with this logistics element.

1.5 Spares. The determination of spares and repair parts, required to satisfy scheduled and unscheduled maintenance requirements will be established based upon the results of the LORA. To ensure that spares and repair parts recommendations are inconsonance with the total integrated logistics support concept, the trainer ILS management shall establish a supply operations team during the initial phase of the support program.

This team will establish the requirements to be included in the interim items list and will identify which of these items to recommend for inclusion in the interim support items kit.

Based on the results of the LORA, the team will identify and, with the approval of the PCO, procure the items required for the interim support items (ISI) kit. Basically, this kit will contain those items required to maintain the trainer in an operational condition for a government specified period commencing with government acceptance of the trainer.

ANNEX II

INTERFACE SPECIFICATION

1.0 COMMUNICATIONS

1.1 Scope. This specification covers the transmission and communication between a maintenance trainer interactive student workstation computer and a instructor workstation computer. The student workstation is assumed to be an intelligent device which physically simulates the actual environment for which the trainer is designed.

1.2 Device description. The instructor workstation can have a variety of microprocessors as the host (8 bit or 16 bit) along with various types of authoring languages that could range from machine language based to some higher order language such as PASCAL. This specification is intended to lay the ground work for a common data entry set on the part of both the programmer and the lesson author, independent of the system type of language base. The workstation shall be equipped with a dedicated RS232C communications channel for interaction between itself and the 3D simulation element. This signal will exist through a dedicated bulkhead 25 pin JEDEC "D" type connector that is clearly marked for its intended purpose.

1.3 Interface. The communications between the instructor station and the student station will utilize a standard dedicated RS232C channel.

1.3.1 Format. The data transmission will be asynchronous at 9600 BAUD. Each data byte will be transmitted as one (1) start bit, eight (8) data bits, one (1) parity bit, and one (1) stop bit. Even data parity will be used.

1.3.2 Message transfer synchronization. The communications channels in the 3D station as a whole unit. To facilitate the message transfer, the 2D station must achieve a synchronization with the 3D station. To accomplish this, the 2D station will send a single ENQ character and then wait for a response. This response will occur within 65 milliseconds. The 3D station will, during its normal polling sequence, encounter the ENQ code. The 3D

station will then suspend further normal activity and enter a receive message mode. In this mode the 3D station transmits an ACK to acknowledge the request to send the message and monitors the communications channel until the end of message is encountered. After one message is received, the 3D station is free to leave the receive message mode and continue with its normal processing. The 3D is not required to accept more than one message per processing cycle nor will the 3D remain in the receive message mode for more than 250 milliseconds. Any message not completed within the allotted time will be abandon and acknowledged with a NAK. Before each message is transmitted to the 3D station synchronization must be established.

Each message is transferred out of the 3D station as a whole unit. To insure the intended receiver is available to receive the message, the 3D must achieve a synchronization with the 2D station. To accomplish this, the 3D station will sent a single ENQ character and then wait for a response. This response must occur within 15 milliseconds. The 2D station must then transmit an ACK to acknowledge the request to send the message and monitor the communications channel until the end of the message is encountered. After one message is received, the 2D station is free to discontinue synchronization. The 2D is not required to accept more than one message per synchronization nor should it remain in the receive message mode for more than 250 milliseconds. Any message not completed within the allotted time will be abandon and acknowledged with a NAK. Before each message is transmitted to the 2D station synchronization must be established.

The short wait time for synchronization on the part of the 3D station avoids the deadlock situation where both 2D and 3D units are attempting to achieve synchronization for a message transmission. In this case, the 3D unit will fail to receive a synchronization ACK within the allotted time and abandon the transmission. The 3D is thus freed to acknowledge the transmission request from the 2D within the required timeframe.

NOTE: After transmitting an ENQ character and awaiting synchronization, ANY character received other than an ACK is ignored by the 2D.

1.3.3 Message protocol. Each message transmission will begin with a the code sequence DLE STX. This heading identifies the beginning of a message of transparent data (allowing data codes of 00 to 255). These message is ended when the control sequence DLE ETB is detected. Each message is followed by a checksum. This one (1) byte value is the binary sum, without carry, of all codes transmitted in the message after, but not including, the heading. The ending sequence is included in the checksum.

To guarantee the uniqueness of control sequences as distinguished from data all occurrences of the code DLE within the message shall be transmitted as the sequence DLE DLE. However, only one DLE code is included in the checksum.

Both transmitting and receiving stations will independently calculate the checksum for each message. Upon detecting the end of a message, the receiving station will compare its calculated checksum to the received checksum. If the values match, the receiving station will transmit an ACK. The transmitting station, upon completing the transmission of a message, will wait until it receives a reply from the receiving station. If the transmitting station receives a ACK in reply to the transmitted message, it continues with its normal processing duties. If the receiving station's calculated checksum does not match the received value, the receiving station will discard the data received and transmit a NAK. The transmitting station upon receipt of a NAK will retransmit the message. The transmitting station will attempt to pass a message a total of three (3) times. If after three attempts the transmitter has not successfully received a ACK acknowledgement, the station will fall into a error handling routine.

If a reply is not received by the transmitting station within 5 milliseconds after the transmission of a message, a NAK shall be assumed.

If a new code is not received for 2 milliseconds during the reception of a message, the receiving station will discard the received data and transmit a NAK.

Any characters received after acknowledging a synchronization ENQ and before the command sequence DLE STX is received shall be ignored.

If during the receipt of a message, after the command sequence DLE STX is received, a command sequence other then DLE DLE or DLE ETB is received, the receiving station will discard the data received, transmit a NAK and refrain from collecting received data until a new DLE STX sequence is received.

1.3.4 Message data format. Within each message transmitted to the 3D station, the first byte of data will be the device code, the second byte will be the keycode, the remaining bytes, if any, are parameters for the keycode.

The device code identifies the processor to whom the message is addressed. This code is always OEO hex.

No device code is included in any message transmitted by the 3D station.

ANNEX III

AMTESS COST PROJECTION ASSESSMENT

INTRODUCTION

The purpose of this annex is to present the AMTESS cost projection assessment and to describe the methodology for developing the assessment of projected costs for the purpose of evaluating and optimizing Life Cycle Cost (LCC). The cost assessment is an extension of the Life Cycle Cost and Design to Unit Production Cost (DTUPC) assessments conducted under Phase I activities. AMTESS subsystem cost assessments have been developed in accordance with Army LCC Matrix cost elements defined in DA Pamphlets 11-2, 11-3 and 11-4. Cost was allocated for each subsystem and component assemblies. Cost allocations highlight recurring and non-recurring costs, cost drivers for development, production, operations and support and critical system requirements (e.g. Reliability, Maintainability, ILS, environment, etc.). These assessments are not intended to constitute exhaustive survey of all possible specific elements of cost but to show the methodology and tradeoffs used in allocating LCC for each AMTESS subsystem.

The overall framework for cost projection assessments is the Army Life Cycle Cost Matrix. The rows of this matrix show the cost elements of the three major life cycle phases: Research & Development, Investment and Operating & Support. The columns of this matrix are used for each subsystem of the AMTESS. Each cost category will be calculated using the equations shown in above DA pamphlets or other applicable cost estimating relationships. Documentation will include the Cost Data and Variable Explanation Sheets required in these pamphlets.

Procedure for LCC Projection Assessment

The procedure for determining the projected LCC Projection Assessment is shown in the Flow chart of Figure A-1. It begins with a review of contract requirements and the training scenario. This includes items such as quantity, sites, operating hours, facilities, ILS, maintenance concept, etc. Cost sources are identified such as purchase orders, manufacturing estimates, factors from the Army Force Planning Cost Handbook, etc. Cost equations from the DA pamphlets are utilized or applicable new ones developed as required for

each category of the Army LCC matrix. Estimates are made for each category of R&D, Investment and O&S of the life cycle. Critical design parameters influencing LCC are determined such as reliability, maintainability, environment, ILS, etc. Tradeoffs are performed on a system level as well as to select optimum hardware and software/courseware. The results are documented using the Army LCC matrix Cost Data and Variable Explanation sheets of the DA pamphlets. The Army LCC matrix and typical Cost Data and Variable Explanation sheets are given in Figures A-2 and A-3, respectively. Cost Allocations and drivers are presented using pie and bar charts and sensitivity graphs. These will be used to evaluate costs and determine those areas there cost reduction efforts will be most effective.

Annex 3
pg 3

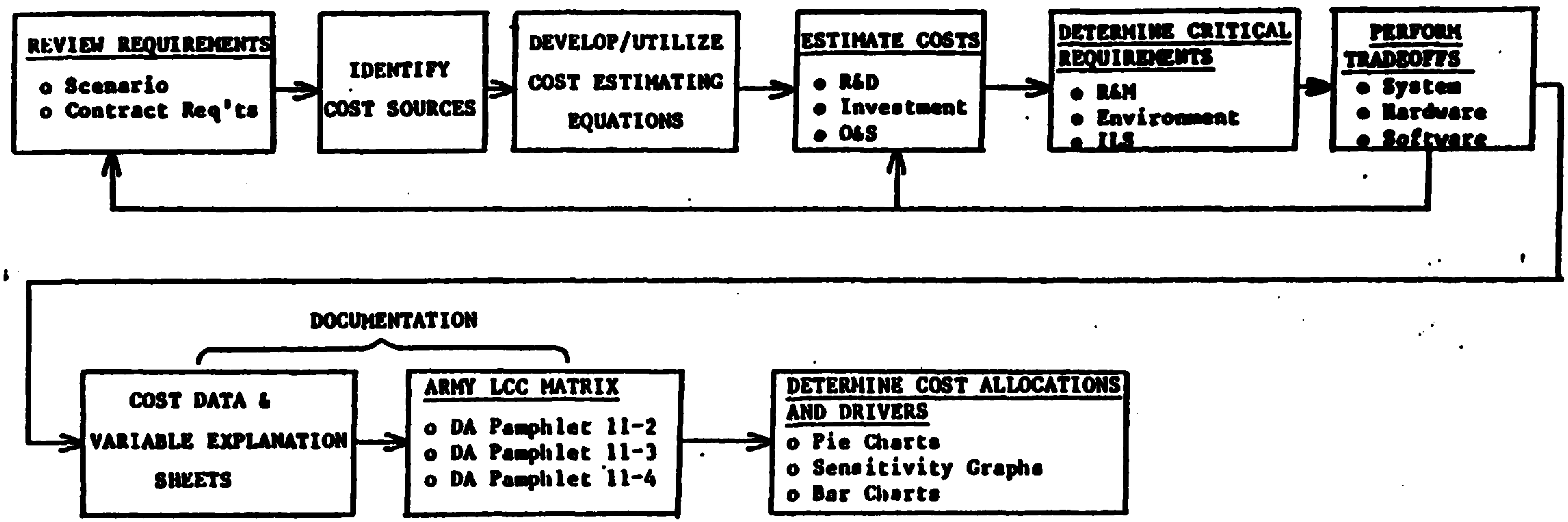


FIGURE A-1 FLOW CHART FOR AMTESS PROJECTED LCC ASSESSMENT

ARMY LIFE CYCLE COST MATRIX

Line	[illegible]	CES No.	Program Structure* / Cost Element	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1		1.0	RESEARCH AND DEVELOPMENT													
2	[illegible]	1.01	DEVELOPMENT ENGINEERING													
3	[illegible]	1.02	PRODUCIBILITY ENGINEERING AND PLANNING (PEP)													
4	[illegible]	1.03	TOOLING													
5	[illegible]	1.04	PROTOTYPE MANUFACTURING													
6	[illegible]	1.05	DATA													
7	[illegible]	1.06	SYSTEM TEST AND EVALUATION													
8	[illegible]	1.07	SYSTEM/PROJECT MANAGEMENT													
9	[illegible]	1.08	TRAINING													
10	[illegible]	1.09	FACILITIES													
11	[illegible]	1.10	OTHER													
12		2.0	INVESTMENT													
13	[illegible]	2.01	NON-RECURRING INVESTMENT													
14	[illegible]	2.02	PRODUCTION													
15	[illegible]	2.03	ENGINEERING CHANGES													
16	[illegible]	2.04	SYSTEM TEST AND EVALUATION													
17	[illegible]	2.05	DATA													
18	[illegible]	2.06	SYSTEM/PROJECT MANAGEMENT													
19	[illegible]	2.07	OPERATIONAL/SITE ACTIVATION													
20	[illegible]	2.08	TRAINING													
21	[illegible]	2.09	INITIAL SPARES AND REPAIR PARTS													
22	[illegible]	2.10	TRANSPORTATION													
23	[illegible]	2.11	OTHER													
24		3.0	OPERATING AND SUPPORT COST													
25		3.01	MILITARY PERSONNEL													
26	[illegible]	3.011	CREW PAY AND ALLOWANCES													
27	[illegible]	3.012	MAINTENANCE PAY AND ALLOWANCES													
28	[illegible]	3.013	INDIRECT PAY AND ALLOWANCES													
29	[illegible]	3.014	PERMANENT CHANGE OF STATION													
30		3.02	CONSUMPTION													
31	[illegible]	3.021	REPLENISHMENT SPARES													
32	[illegible]	3.022	PETROLEUM, OIL AND LUBRICANTS													
33	[illegible]	3.023	UNIT TRAINING, AMMUNITION AND MISSILES													
34		3.03	DEPOT MAINTENANCE													
35	[illegible]	3.031	LABOR													
36	[illegible]	3.032	MATERIAL													
37	[illegible]	3.033	TRANSPORTATION													
38	[illegible]	3.04	MODIFICATIONS, MATERIAL													
39		3.05	OTHER DIRECT SUPPORT OPERATIONS													
40	[illegible]	3.051	MAINTENANCE, CIVILIAN LABOR													
41	[illegible]	3.052	OTHER DIRECT													
42		3.06	INDIRECT SUPPORT OPERATIONS													
43	[illegible]	3.061	PERSONNEL REPLACEMENT													
44	[illegible]	3.062	TRANSIENTS, PATIENTS AND PRISONERS													
45	[illegible]	3.063	QUARTERS, MAINTENANCE AND UTILITIES													
46	[illegible]	3.064	MEDICAL SUPPORT													
47	[illegible]	3.065	OTHER INDIRECT													
48			TOTAL SYSTEM COST (LESS SUNK)													
49	[illegible]	4.0	SUNK COST													
50			TOTAL SYSTEM COST (WITH SUNK)													

[illegible]

*[illegible]

**[illegible]

CELL NO: 3.012

DATE: ____________

COST DATA SHEET

ITEM: O&S, MAINTENANCE PAY AND ALLOWANCES

COST DATA EXPRESSION:

3.012 = Quantity of Operational Equipment x Failure-Rate x Annual Operating Hours x Operating Years x Mean Time to Repair x Annual Pay Rate ÷ Maintenance Man Hours per Year.

INCLUDES:

Base pay and allowances.

EXCLUDES:

Annual Factors above Base Pay and Allowances.

FINAL COST MODEL EXPRESSION:

		Automotive	Missile
3.012 =	$\frac{\text{Quantity} \times FR \times HOP \times OLC \times MTR}{MHY} \times MPR$ =	xxxxx	xxxxx

VARIABLES ARE:

	Automotive	Missile
[illegible] = Quantity of Operational Equipment	300	300
FR = Failure Rate	3927	4432 (10^6)
HOP = Hours of Operation per AN/TSS Per Year	4000	4000
OLC = Operational Life cycle (yrs)	15	15
MTR = Meantime to Repair (Operational Level)	1 Hr.	1 Hr.
MPR = Maintenance Man Pay Rate (E4) Yr.	xxxx	xxxx
MHY = Maintenance Man Hours Per Year	1676	1676

VARIABLE NO: FR

CELL NO: 3.012

VARIABLE EXPLANATION SHEET

ITEM: FR-FAILURE RATE

CURRENT VALUE BEING USED:

		TOTAL Automotive	TOTAL Missile
2D Access Station = 1,987 Automotive 3D Station = 1,940 Missile 3D Station = 2,445	} Failures Per Million Operating Hours	3,927	4,432

DESCRIPTION OF HOW VALUE DERIVED:

Analysis of individual parts/components contained in each station and applying failure rates to same.

See Tables: 1.0 through 4.0

SOURCE:

Vendor supplied information
MIL-Handbook-217
Reliability Test Data on Similar Equipment.

5

Examples of Cost Projection Assessment

Two AMTESS types have been selected as typical examples of the assessment of projected costs. One is a high complexity missile radar while the other is a lower complexity automotive system illustrating the range to be expected of projected costs. The cost projection assessments are not to be construed as cost projections for future AMTESS units but only as examples of the type of calculations to be performed for the full scale production phase. The methodology is depicted in Figures A-4 and A-5 for the missile radar and automotive systems, respectively. It consists of determining R&D, Investment and Operating and Support costs for each subsystem and component assembly. The cost projection assessment outputs will indicate recurring and non-recurring costs, cost allocations and drivers and critical system requirements.

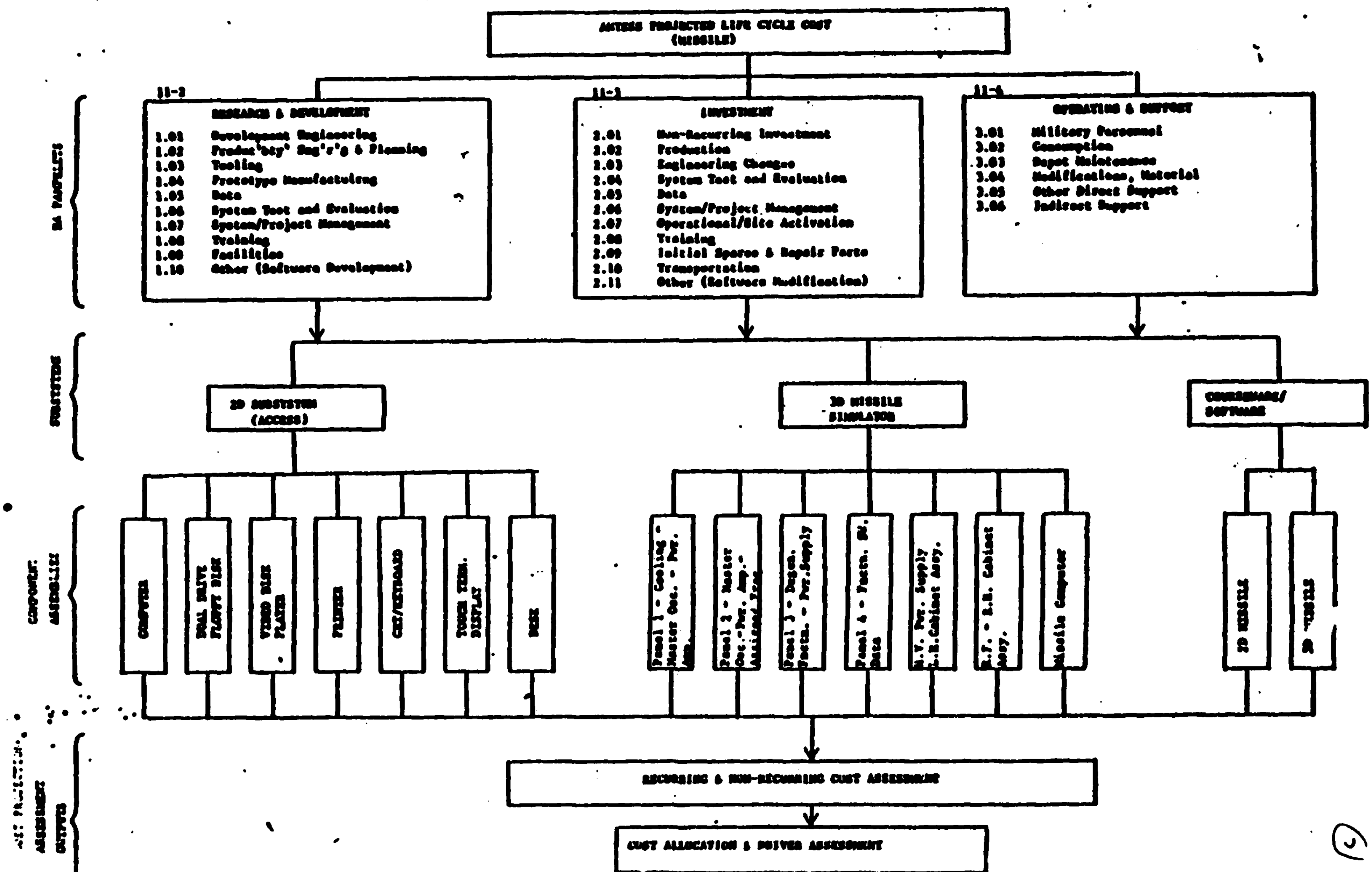


FIGURE A-4: METHODOLOGY FOR ANTESS (MISSILE)

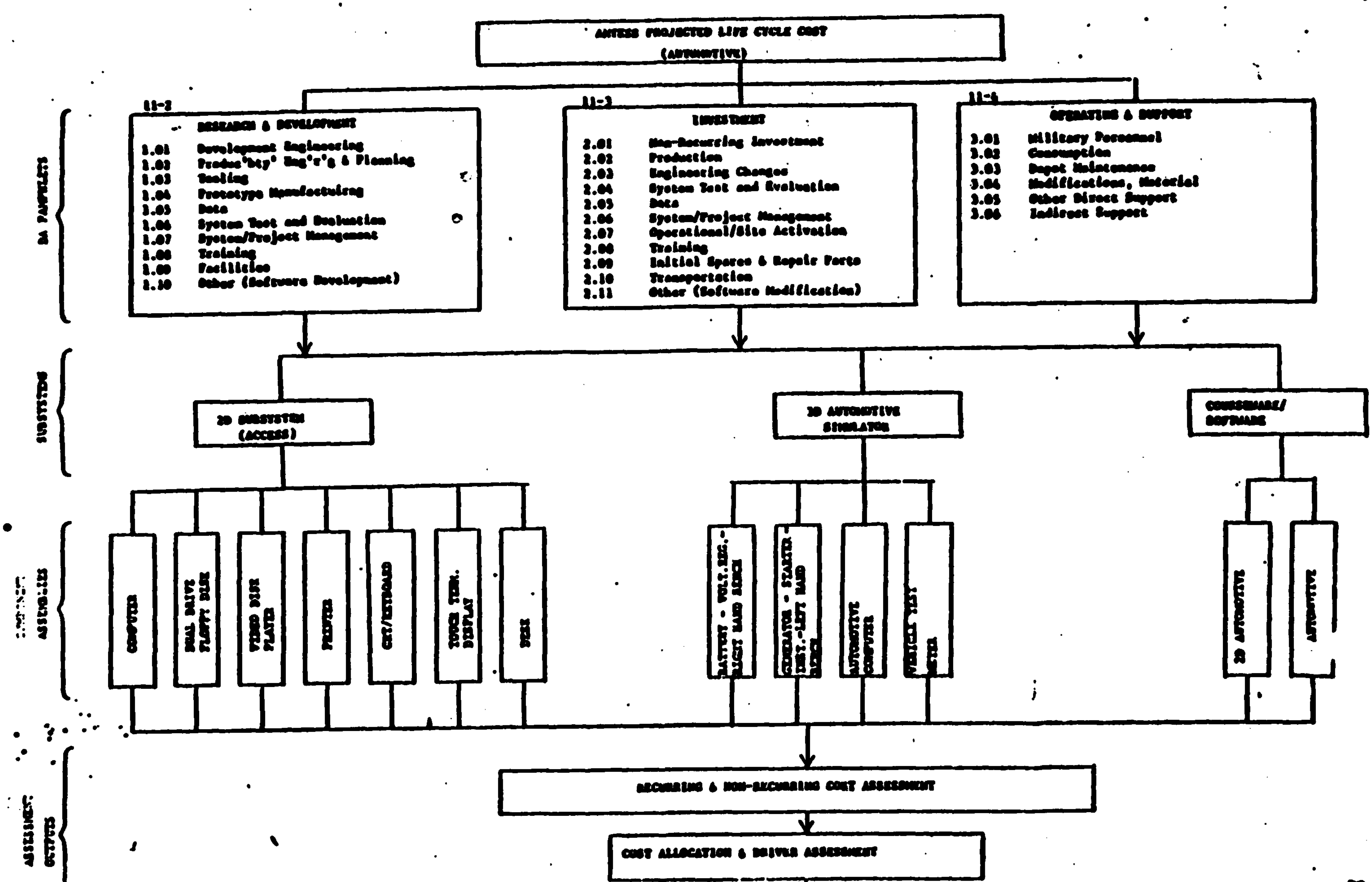


FIGURE 4-3: METHODOLOGY FOR ANTESS (AUTOMOTIVE) [illegible] LIFE CYCLE COST

AMTESS Equipment Breakout

For the examples used, the 2-D Subsystem Automotive Common Core Evaluation Stimulation System (ACCESS) was the same for both Missile Radar and Automotive units and consisted of the following component assemblies.

- o Computer
- o Dual Drive Floppy Disk
- o Video Disk Player
- o Printer
- o CRT/Keyboard
- o Tough Terminal Display
- o Desk

The 3-D Missile Radar Simulator Subsystem contained the following components.

- o Panel 1 - Cooling - Master Osc. - Power Amp
- o Panel 2 - Master Osc. - Power Amp - Assigned Frequency
- o Panel 3 - Degen. Function - Power Supply
- o Panel 4 - Function Switch Data
- o H.V Power Supply - Left Hand Cabinet Assy.
- o R.F. - Right Hand Cabinet Assy.
- o Missile Computer

The 3-D Automotive Simulator Subsystem consisted of the following component assemblies:

- o Battery - Volt. Reg - Right Hand Bench
- o Gen. - Starter - Inst. - Left Hand Bench
- o Automotive Computer
- o Vehicle Test Meter

The 2-D and both 3-D subsystems had courseware/software programs associated with them.

Results of Example Cost Projection Assessments

Figure A-6 shows the relative costs of each cost element in the Army LCC matrix as a percentage of total LCC. A production quantity of 300 is assumed for each type of AMTESS. R&D, Investment and O&S costs were 2.00, 68.50 and 29.50% for the automotive AMTESS and 2.23, 71.77 and 26.02 for the Missile Radar AMTESS of total LCC, respectively. The Army LCC matrix shows the percentage for each cost element.

FIGURE A-6 AMTESS RELATIVE COSTS AS A PERCENTAGE OF TOTAL LCC - 300 PRODUCTION UNITS EACH

[illegible]	System / COST ELEMENT	AUTOMOTIVE TOTAL	AUTOMOTIVE 3D SUBSYSTEM	AUTOMOTIVE 2D SUBSYSTEM		MISSILE TOTAL	MISSILE 3D SUBSYSTEM	MISSILE 2D SUBSYSTEM		
1.0	Research and Development	2.00	1.66	0.34		2.23	1.97	0.26		
1.01	Development Engineering	0.34	0.25	0.09		0.40	0.33	0.07		
1.02	Producibility Engineering and Planning	0.04	0.03	0.01		0.04	0.03	0.01		
1.03	Tooling	-	-	-		-	-	-		
1.04	Prototype Manufacturing	0.32	0.18	0.14		0.33	0.23	0.10		
1.05	Data	0.08	0.05	0.02		0.09	0.07	0.02		
1.06	System Test and Evaluation	0.09	0.07	0.02		0.11	0.09	0.02		
1.07	System/Project Management	-	-	-		-	-	-		
1.08	Training	-	-	-		-	-	-		
1.09	Facilities	-	-	-		-	-	-		
1.10	Other (Software/Courseware Development)	1.13	1.09	0.04		1.25	1.22	0.03		
2.0	Investment	60.30	30.10	29.40		71.77	49.85	21.92		
2.01	Non-Recurring Investment	0.31	0.30	0.01		0.35	0.34	0.01		
2.02	Production	58.50	33.40	25.10		61.56	42.79	18.77		
2.03	Engineering Changes	-	-	-		-	-	-		
2.04	System Test and Evaluation	-	-	-		-	-	-		
2.05	Data	0.10	0.07	0.03		0.12	0.09	0.03		
2.06	System/Project Management	-	-	-		-	-	-		
2.07	Operational/Site Activation	0.42	0.21	0.21		0.31	0.15	0.15		
2.08	Training	0.15	0.07	0.08		0.22	0.15	0.07		
2.09	Initial Spares and Repair Parts	8.30	4.70	3.60		8.80	6.12	2.68		
2.10	Transportation	0.55	0.27	0.27		0.61	0.31	0.30		
2.11	Other	-	-	-		-	-	-		
3.0	Operating and Support Cost	29.50	15.05	14.45		26.02	15.28	10.74		
3.01	Military Personnel	2.33	1.15	1.18		1.96	1.08	0.88		
3.011	Instructor Pay and Allowances	-	-	-		-	-	-		
3.012	Maintenance Pay and Allowances	1.85	0.91	0.94		1.56	0.86	0.70		
3.013	Indirect Pay and Allowances	0.44	0.22	0.22		0.37	0.20	0.16		
3.014	Permanent Change of Station	0.05	0.02	0.03		0.04	0.02	0.02		
3.02	Consumption	6.28	3.58	2.70		6.60	4.59	2.01		
3.021	Replenishment Spares	6.28	3.58	2.70		6.60	4.59	2.01		
3.022	Petroleum, Oil and Lubricants	-	-	-		-	-	-		
3.023	Unit Training, Ammunition and Missiles	-	-	-		-	-	-		
3.03	Depot Maintenance	18.28	9.03	9.25		15.37	8.48	6.89		
3.031	Labor	-	-	-		-	-	-		
3.032	Material	-	-	-		-	-	-		
3.033	Transportation	-	-	-		-	-	-		
3.04	Modifications, Material	-	-	-		-	-	-		
3.05	Other Direct Support Operations	-	-	-		-	-	-		
3.051	Maintenance Civilian Labor	-	-	-		-	-	-		
3.052	Other Direct	-	-	-		-	-	-		
3.06	Indirect Support Operations	2.60	1.28	1.32		2.08	1.12	0.96		
3.061	Personnel Replacement	2.00	1.02	0.98		1.67	0.92	0.75		
3.062	Transients, Patients and Prisoners	0.14	0.07	0.07		0.12	0.06	0.06		
3.063	Quarters, Maintenance and Utilities	0.11	0.06	0.06		0.08	0.04	0.04		
3.064	Medical Support	0.06	0.03	0.03		0.05	0.03	0.02		
3.065	Other Indirect	0.19	0.10	0.10		0.16	0.08	0.08		
	Total System Cost	100	55.81	44.19		100	67.09	32.91		

9

LCC versus Quantity

Graphs of relative unit LCC versus the production quantity for the high and low complexity AMTESS units are given in Figure A-7. These indicate the range of relative costs to be expected for trainers of different complexities.

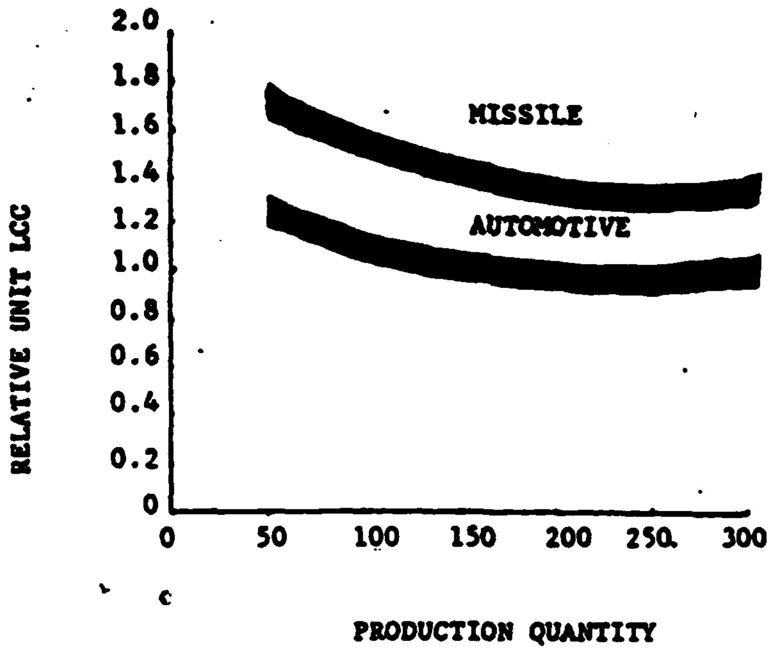
FIGURE A-7

AMTESS RELATIVE UNIT LIFE CYCLE COST *

VS

PRODUCTION QUANTITY

*Normalized to unit cost of 300 - Automotive AMTESS units



Cost Allocations & Drivers

In the following figures, costs allocations and drivers are indicated using pie charts of relative costs.

Figure A-8 shows the LCC distribution by phase for a production quantity of 300 units of each type of AMTESS. Investment cost is the largest followed by O&S and R&D. O&S is reasonable in relation to Investment because the equipment is commercial and is operating in a benign environment requiring low maintenance.

Figure A-9 shows the R&D cost drivers. Peculiar software/courseware development is the largest cost followed by development engineering and unique prototype manufacturing (3D).

Figure A-10 shows the software/courseware (unique and common) versus hardware costs during R&D. The largest cost is software/courseware development (unique) followed by 3D hardware, 2D hardware and software/courseware (common).

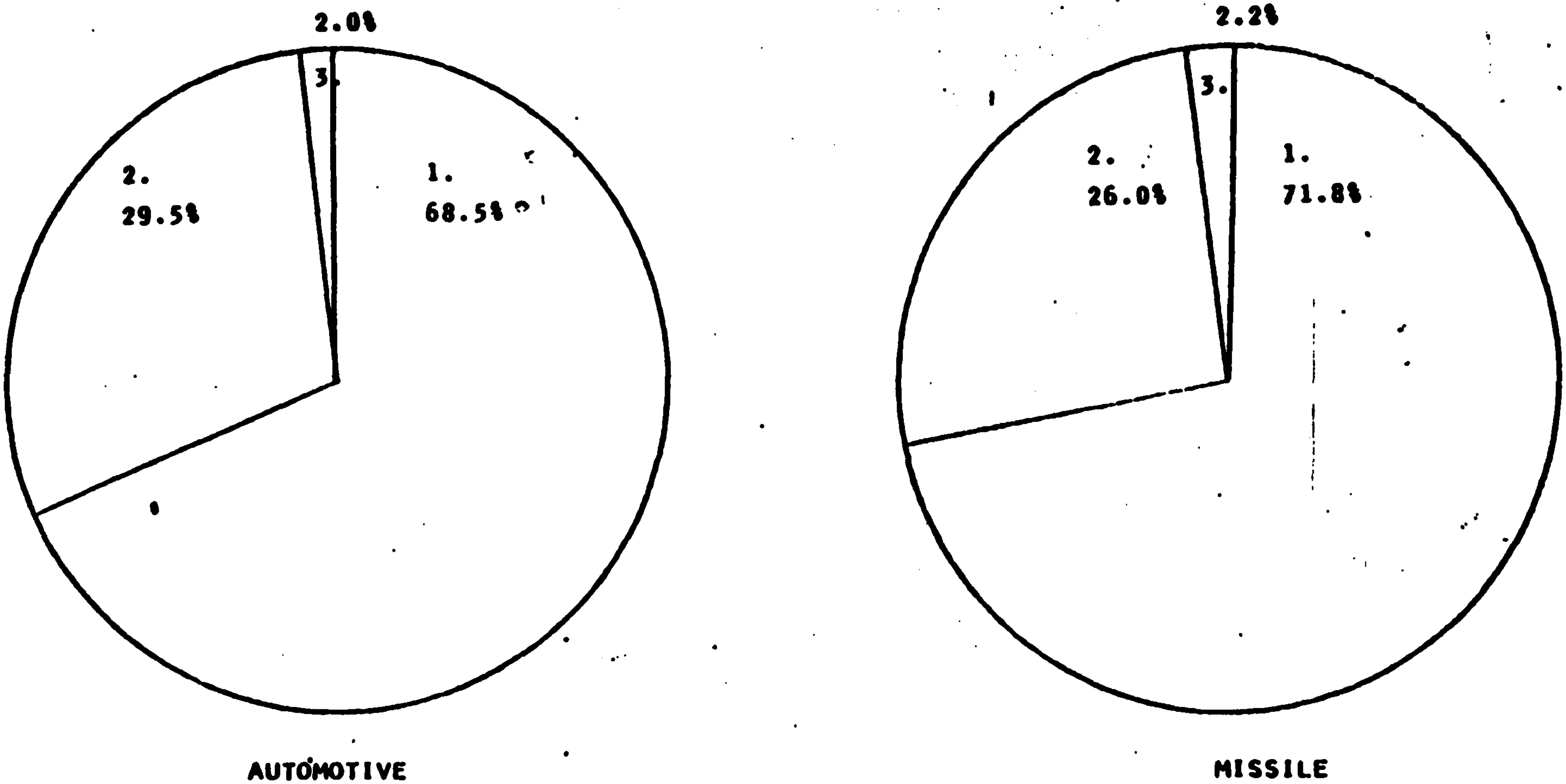
Investment costs drivers are shown in Figure A-11. Production accounts for the largest cost followed by Initial Spares & Repair Parts.

Operating and Support Cost Drivers are shown in Figure A-12. Depot maintenance is the largest part of the cost followed by consumption, Indirect Support Operations and military personnel.

Figure A-13 shows the ratio of 3D to 2D hardware costs. Figure A-14 shows the cost drivers of 2D hardware. Figure A-15 shows the hardware cost drivers of the 3D automotive AMTESS while Figure A-16 shows those of the 3D missile radar AMTESS.

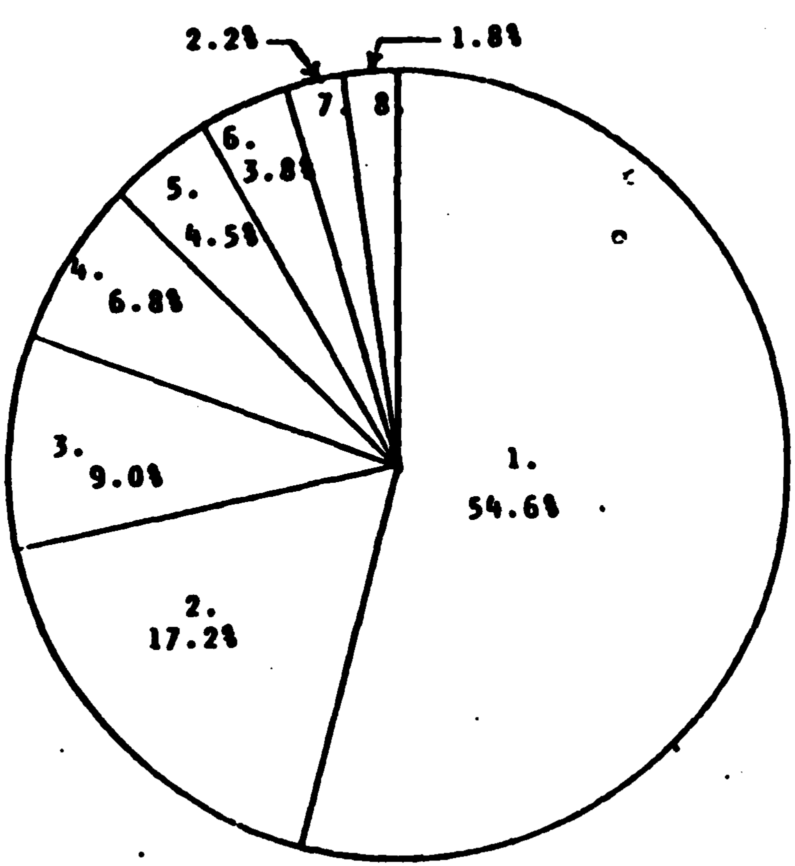
AMTESS

FIGURE A-8 COST DISTRIBUTION BY PHASE - 300 PRODUCTION UNITS EACH



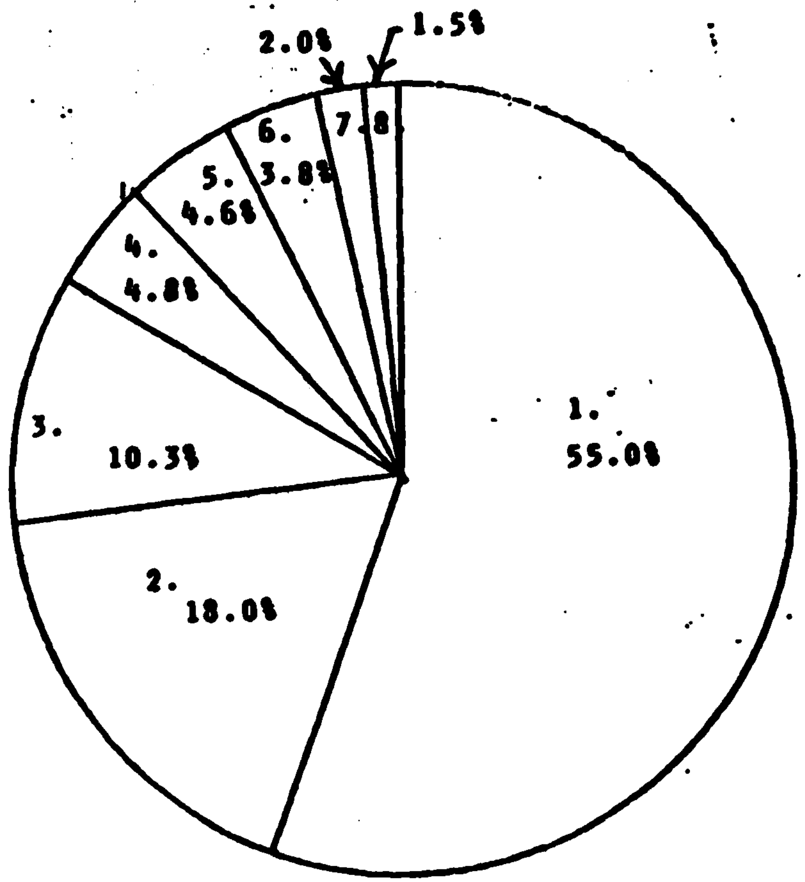
1. INVESTMENT
2. OPERATING AND SUPPORT
3. RESEARCH AND DEVELOPMENT

FIGURE A-9 RESEARCH AND DEVELOPMENT COST DRIVERS



AUTOMOTIVE

1. PECULIAR SOFTWARE/COURSEWARE DEVELOPMENT
2. DEVELOPMENT ENGINEERING
3. UNIQUE PROTOTYPE MANUFACTURING (3D)
4. COMMON PROTOTYPE MANUFACTURING (2D ACCESS)
5. SYSTEM TEST AND EVALUATION
6. DATA
7. COMMON SOFTWARE DEVELOPMENT
8. PRODUCIBILITY ENGINEERING AND PLANNING



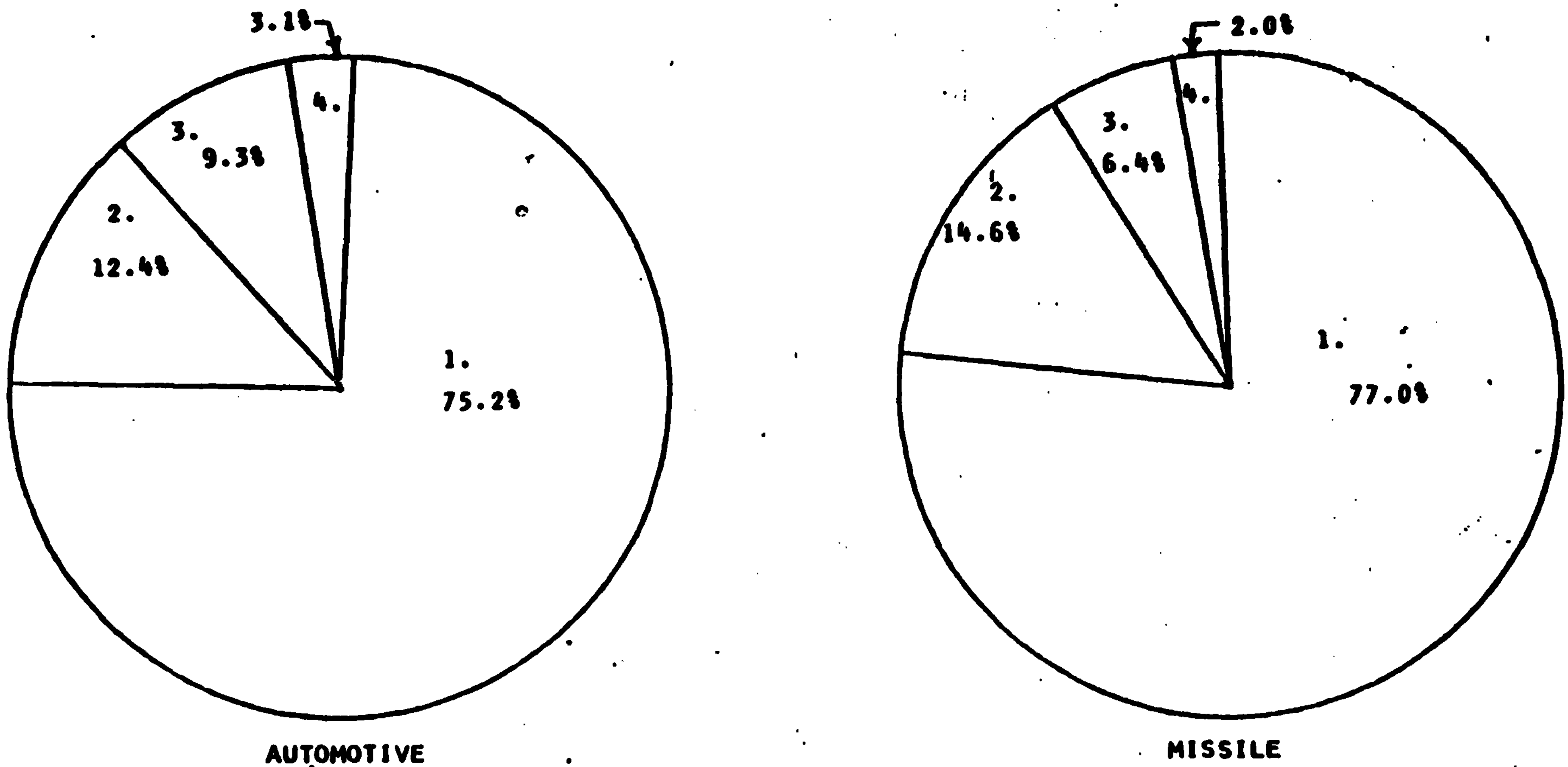
MISSILE

1. PECULIAR SOFTWARE/COURSEWARE DEVELOPMENT
2. DEVELOPMENT ENGINEERING
3. UNIQUE PROTOTYPE MANUFACTURING (3D)
4. SYSTEM TEST AND EVALUATION
5. COMMON PROTOTYPE MANUFACTURING (2D ACCES
6. DATA
7. PRODUCIBILITY ENGINEERING AND PLANNING
8. COMMON SOFTWARE DEVELOPMENT

FIGURE A-10

AMTESS

RESEARCH AND DEVELOPMENT SOFTWARE/COURSEWARE VS HARDWARE DISTRIBUTION

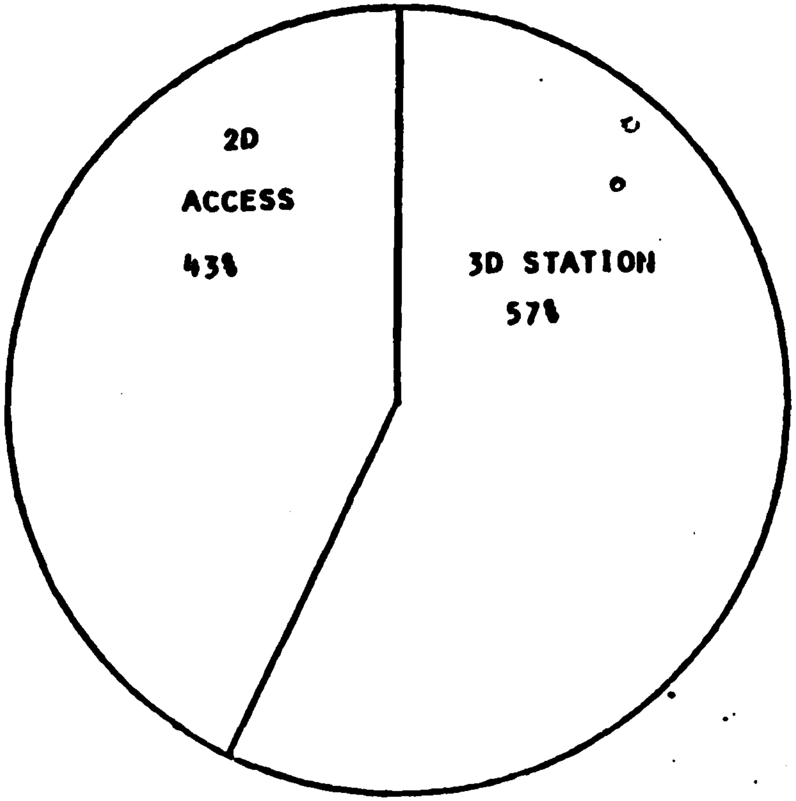


1. SOFTWARE/COURSEWARE DEVELOPMENT (UNIQUE)
2. 3D STATION
3. AUTOMATIC COMMON CORE EVALUATION SIMULATION SYSTEM (2D ACCESS)
4. SOFTWARE/COURSEWARE DEVELOPMENT (COMMON)

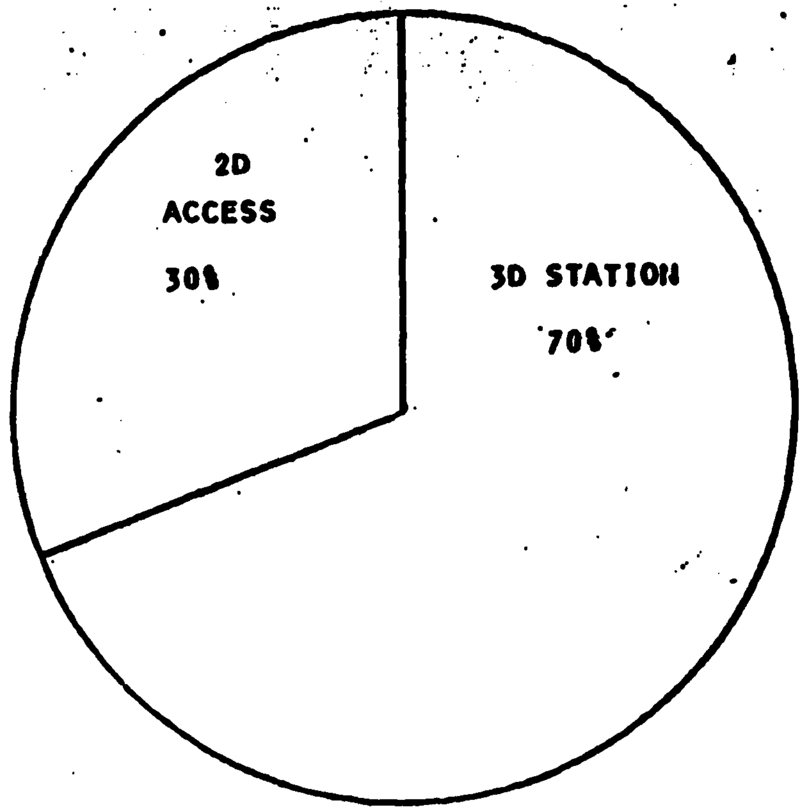
16

AMTOSS

FIGURE A-13 SUBSYSTEM COST DISTRIBUTION



AUTOMOTIVE



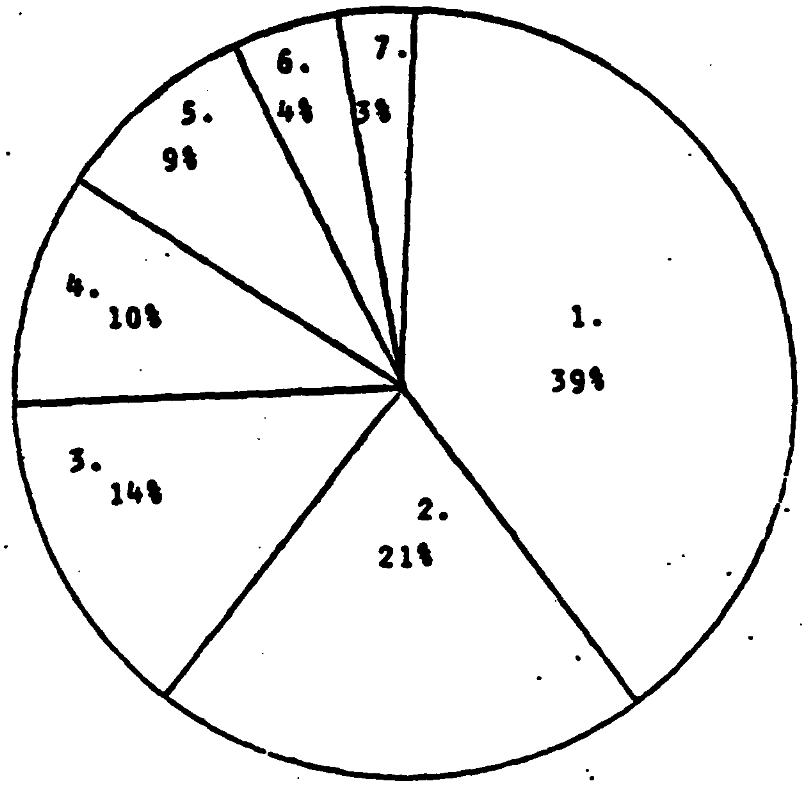
MISSILE

FIGURE A-14

AMTESS

2D AUTOMATIC COMMON CORE EVALUATION SIMULATION SYSTEM (ACCESS)

HARDWARE COST DRIVERS



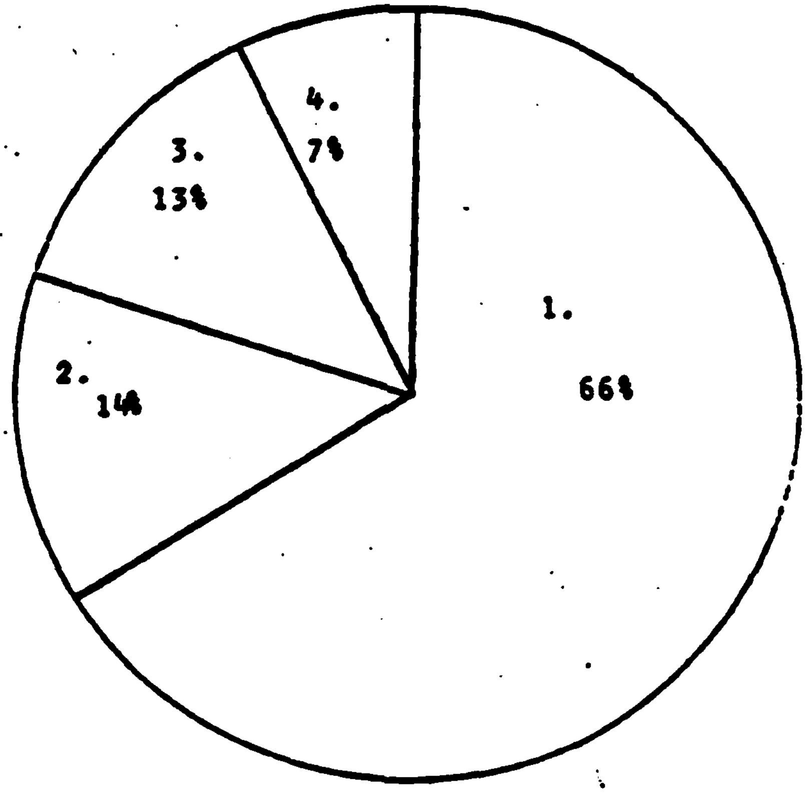
1. COMPUTER
2. DUAL DRIVE FLOPPY DISK
3. VIDEO DISK PLAYER
4. TOUCH TERMINAL DISPLAY
5. CRT/KEYBOARD
6. DESK
7. PRINTER

FIGURE A-15

AMTESS

AUTOMOTIVE 3D STATION

HARDWARE COST DRIVERS



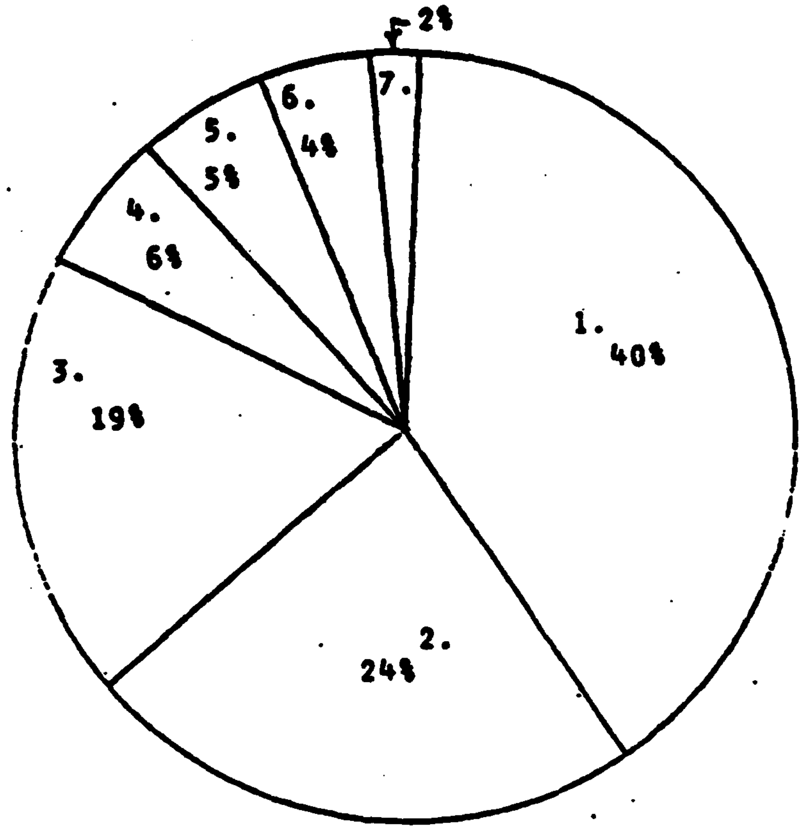
1. GENERATOR, STARTER AND INSTRUMENT BENCH
2. COMPUTER
3. BATTERY, VOLTAGE REGULATOR BENCH
4. VEHICLE TEST METER

FIGURE A-16

AMTESS

MISSILE 3D STATION

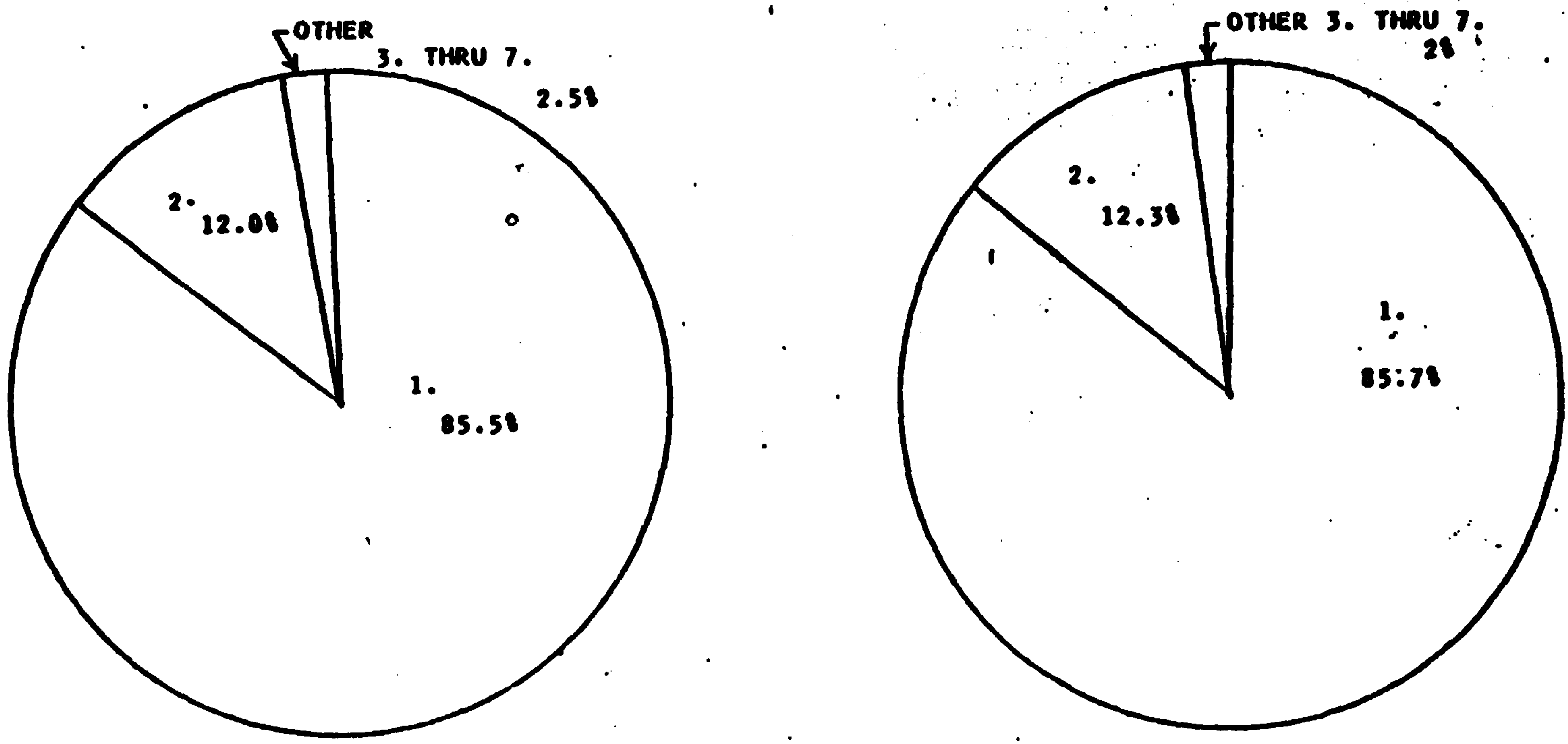
HARDWARE COST DRIVERS



1. R.F. - R.H. CABINET A-SEMBLY .
2. H.V. POWER SUPPLY - L.H. CABINET ASSEMBLY
3. COMPUTER
4. PANEL NO. 2
5. PANEL NO. 1
6. PANEL NO. 3
7. PANEL NO. 4

AMCCESS

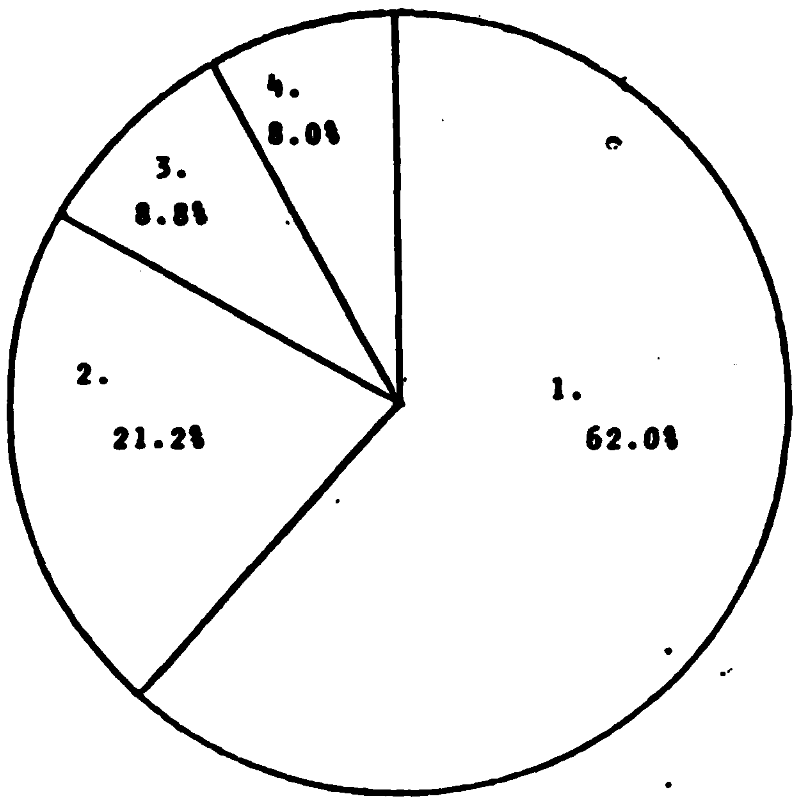
FIGURE A-11 INVESTMENT COST DRIVERS - 300 PRODUCTION UNITS EACH



1.	PRODUCTION	85.5% AUTOMOTIVE	85.7% MISSILE
2.	INITIAL SPARES & REPAIR PARTS	12.0%	12.3%
3.	TRANSPORTATION	0.9%	0.6%
4.	OPERATIONAL/SITE ACTIVATION	0.6%	0.5%
5.	NON-RECURRING INVESTMENT	0.4%	0.4%
6.	TRAINING	0.3%	0.3%
7.	DATA	0.2%	0.2%

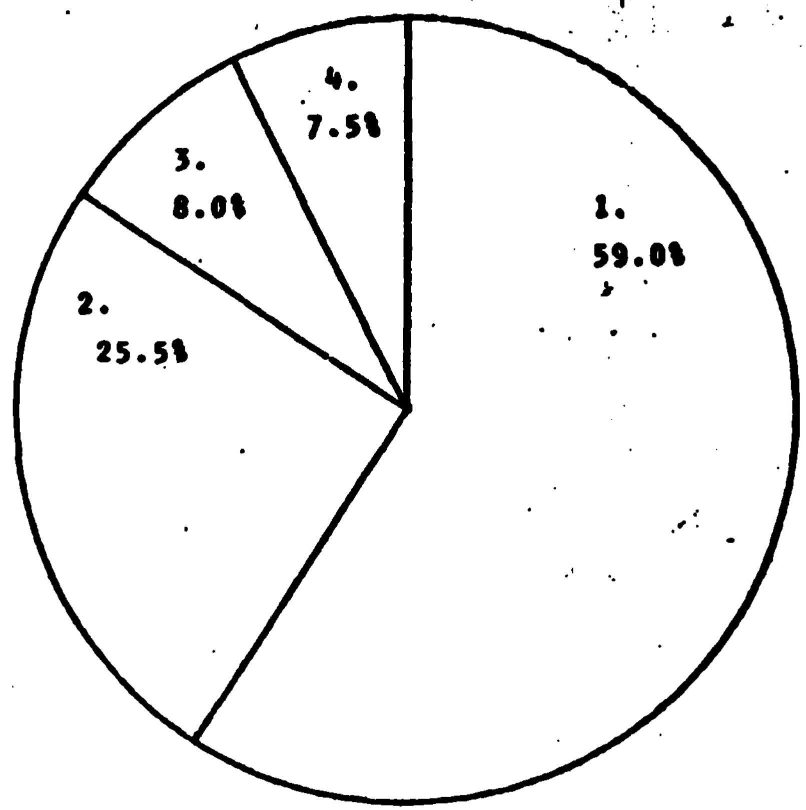
AMTESS

FIGURE A-12 OPERATING AND SUPPORT COST DRIVERS - 300 PRODUCTION UNITS EACH



AUTOMOTIVE

1. DEPOT MAINTENANCE
2. CONSUMPTION
3. INDIRECT SUPPORT OPERATIONS
4. MILITARY PERSONNEL



MISSILE

1. DEPOT MAINTENANCE
2. CONSUMPTION
3. INDIRECT SUPPORT OPERATIONS
4. MILITARY PERSONNEL